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REPORT OF RESULTS OF SAMPLING THE ATMOS-
PHERE IN THE DETROIT RIVER AREA DURING
1952

George D. Clayton, et al

Environmental Health Center
Cincinnati, Ohio

1 January 1954

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INTERNATIONAL JOINT COMMISSION

TECHNICAL ADVISORY BOARD
ON AIR POLLUTION

REPORT ON 1952
ENVIRONMENTAL FINDINGS

NATIONAL TECHNICAL
INFORMATION SERVICE

**INTERNATIONAL JOINT COMMISSION
TECHNICAL ADVISORY BOARD
ON AIR POLLUTION
United States Section**

**Report of Results of Sampling the Atmosphere
In the Detroit River Area
During 1952**

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**January 1, 1954
Detroit, Michigan**

IA

1B

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G L O S S A R Y

Most of the definitions that follow are taken directly or adapted from "Weather Glossary" by A. H. Theissen, published by the United States Weather Bureau.

Anomaly is the departure of a weather element from the long time mean value. The departure may be positive or negative. Hence surface temperature anomaly is the departure of the surface temperature from the long time mean temperature.

Cold front is the line of discontinuity at the earth's surface along which a wedge of cold air is underrunning and displacing a warmer air mass. The cold frontal passage occurs at the time the cold air displaces the warm air at a particular location.

Gradient wind is the wind which blows parallel to curved isobars. It does not occur at the earth's surface due to friction, but is closely realized at a height of, roughly, 1500 feet.

Isobar is a line connecting places having the same barometric pressure.

Lapse rate is the rate of decrease of temperature with elevation. The lapse rate is usually positive, i.e., the temperature falls off with elevation: it is negative when the temperature increases with height as in the case of an inversion. For unsaturated air, if the lapse rate is less than 3 degrees C per 1000 feet, a condition of vertical equilibrium or stability exists whereby an element of air will resist displacement up or down from its original level. If the lapse rate is greater than 3 degrees C per 1000 feet, a condition of instability exists whereby an element of air, if given an upward or downward impulse, will tend to move away with increasing speed from its original level.

Light transmission is the ratio of the amount of light transmitted by a material to the amount incident upon it. In the case of light transmission through air, the amount of light transmitted will decrease as the amount of light scattering and absorbing material present in the air increases.

Mean sea level pressure is the atmospheric pressure as measured at a station plus a correction to reduce the pressure to sea level. The correction depends mainly on the altitude of the station and the temperature at the station.

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Millibar, the unit of atmospheric pressure now in common use by meteorologists, is equal to a force of 1,000 dynes per square centimeter. 1013 millibars is standard atmospheric pressure.

Parts per million (ppm) is parts of substance per million parts of air by volume.

Prevailing wind direction is the direction from which the wind blows with greatest frequency.

Radiosonde is an instrument equipped with elements for determining the pressure, temperature, and relative humidity of the upper air, and with radio units for automatically transmitting the measurements to ground stations. Radiosondes are carried aloft by balloons. In reporting the results of radiosoundings, one of the standard reporting points is the 850 millibar pressure which corresponds roughly to a height of 4800 feet above sea level.

Synoptic weather chart or map depicts simultaneous weather conditions at many observation points. The pattern of atmospheric pressures as indicated by the centers of high and low pressure is one of the main features of the synoptic weather situation.

Total particulate matter is the total weight of the sample collected after drying for two hours in an oven at 110° C. Any material volatilized at this temperature was driven off and not included.

Turbulence consists of the irregular transitory variations in the general airflow, which are manifested by gustiness.

Visibility is the visual range or the distance at which prominent objects can be seen and identified by the normal eye, unaided by special optical devices.

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I. INTRODUCTION

Air pollution along the United States-Canada international boundary line in the Detroit River area has been the subject of much discussion and complaints of residents living on either side of the international boundary line. Vessels plying the international waters were especially subject to criticism as their smoke emissions far exceeded the permissible limits established by the ordinances of the Cities of Detroit and Windsor. The Detroit River is a narrow body of water and as the vessels are in close proximity to land, the citizens on either side of the boundary, depending upon the wind direction, were subjected to the smoke nuisance.

The citizens on the Canadian side also objected to the air pollutants which were discharged in the United States and carried by the wind into Canada. Conversely, residents of the United States complained of the pollutants originating in Canada and carried by the wind into the United States. Thus it may be seen that the air pollution problem in the Detroit-Windsor area is truly international in character.

The governments of the United States and Canada recognized this international problem by signing on January 12, 1949, a Reference requiring their respective governments to study air pollution and its effects on the communities in the Detroit River area.

The purpose of this report is to present the results of the environmental studies conducted on the United States side during the year 1952 and compare some of these results with those obtained in 1951.

This report is the second of a series of reports dealing with the various facets of this comprehensive air pollution investigation. Future reports will present the environmental data being collected and the results of studies that are either in progress or being planned for determining the effects of air pollutants upon health, vegetation, corrosion and safety.

The Reference, which is the basis for this study is as follows:

REFERENCE

January 12, 1949

United States Section
International Joint Commission
Washington 25, D. C.

Sirs:

I have the honor to inform you that representations have been made to the Governments of the United States and Canada to the effect that the air in the vicinity of the cities of Detroit and Windsor on both sides of the international boundary in the area of the Detroit River, is being polluted by the discharge of smoke, soot and fly ash, in quantities sufficient to be detrimental to the citizens of both countries in this area. It has further been represented to the two Governments that vessels passing through the Detroit River are a source of this pollution. Pursuant to the provisions of Article IX of the Boundary Waters Treaty, signed January 11th, 1909, the two Governments have agreed to a joint Reference of this matter to the International Joint Commission. The Commission is requested to inquire into, and to report to the two governments upon the following questions:

1. Is the air over, and in the vicinity of, the cities of Detroit and Windsor, on either side of the International boundary, being polluted by smoke, soot, fly ash or other impurities, in quantities detrimental to the public health, safety or general welfare of the citizens, or to property interests on either side of the International boundary line?
2. If the foregoing question, or any part thereof, is answered in the affirmative, to what extent are vessels plying the waters of the Detroit River, or any of them, contributing to this pollution; what other major factors are responsible and to what extent?

3. If the Commission should find that vessels plying the waters of the Detroit River, or any of them, are responsible for air pollution to an extent detrimental to the public health, safety or general welfare of the citizens, or to the property interests on either side of the international boundary line,
 - (a) what preventive or remedial measures would, in its judgment, be most practical from the economic, sanitary and other points of view?
 - (b) what would be the probable cost of such measures?
 - (c) by whom should cost be borne?

For the purpose of assisting the Commission in making the investigations and recommendations provided for in this Reference, the two governments, upon request, will make available to the Commission the services of engineers and other specially qualified personnel of their respective Governments, and such information and technical data as may have been acquired by such Governments or as may be acquired by them during the course of the investigation.

The Commission should submit its report and recommendations to the two Governments as soon as practicable.

Very truly yours,

Robert A. Lovett
Acting Secretary of State

An identical reference was simultaneously received by the Canadian Section of the International Joint Commission from the Department of External Affairs of Canada.

INTERNATIONAL JOINT COMMISSION

In 1909, by treaty, the United States and Great Britain created the International Joint Commission.

The treaty presents fourteen articles outlining the duties and authority of the Commission. Of special interest is Article IX which discusses the handling of reports by the International Joint Commission.

Article IX

"The High Contracting Parties further agree that any other questions or matters of difference arising between them involving the rights, obligations, or interests of either in relation to the other or to the inhabitants of the other, along the common frontier between the United States and the Dominion of Canada, shall be referred from time to time to the International Joint Commission for examination and report, whenever either the Government of the United States or the Government of the Dominion of Canada shall request that such questions or matters of difference be so referred.

"The International Joint Commission is authorized in each case so referred to examine into and report upon the facts and circumstances of the particular questions and matters referred, together with such conclusions and recommendations as may be appropriate, subject, however, to any restrictions or exceptions which may be imposed with respect thereto by the terms of the reference.

"Such reports of the Commission shall not be regarded as decisions of the questions or matters so submitted either on the facts or the law, and shall in no way have the character of an arbitral award.

"The Commission shall make a joint report to both Governments in all cases in which all or a majority of the Commissioners agree, and in case of disagreement the minority may make a joint report to both Governments, or separate reports to their respective Governments.

"In case the Commission is evenly divided upon any question or matter referred to it for report, separate reports shall be made by the Commissioners on each side to their own Government."

COMMISSIONERS

The International Joint Commission at the present time is composed of the following:

United States

A. O. Stanley, Chairman
Roger B. McWhorter
Eugene W. Weber

- - -

Jesse B. Ellis, Secretary

Canada

A. G. L. McNaughton, Chairman
George Spence
J. Lucien Dansereau

- - -

Miss E. M. Sutherland, Secretary

I I. S U M M A R Y

A Reference signed on January 12, 1949 required a comprehensive air pollution investigation in the Detroit River area. To answer the questions in the Reference, the following objectives were established to (1) determine the sources, nature and amounts of atmospheric contaminants resulting from combustion of fuels, (2) determine the sources, nature and amounts of atmospheric contaminants resulting from industrial processes, (3) determine the effects of meteorological factors on the dissemination and diffusion of atmospheric contaminants, (4) determine the effect of the atmospheric contaminants upon (a) health, (b) vegetation, (c) safety, and (d) economy, and (5) determine controls necessary (vessels only). (a) Cost, and (b) by whom should the cost be borne?

The initial phase of the study was begun in 1951 and was presented in a monograph entitled "Report on 1951 Environmental Findings".

This report presents the environmental and meteorological findings obtained in 1952 and correlation of these data with those obtained in 1951.

Two principal types of instruments were used in the 1952 environmental studies. These were (1) High Volume Air Samplers, using pleated filters to collect air-borne particulate matter, mounted on power poles ten feet from the ground in each sampling area, and (2) two Thomas Autometers, placed in mobile laboratories to record sulfur dioxide concentrations.

Spectrographic procedures were developed to determine some of the elements present in the collected particulate matter. For this report, 2,500 spectrographic analyses were made for specific elements.

During the period August 7 through September 19, 1952, 242 twenty-four hour samples were collected for total particulate matter at nine sampling stations strategically located in Detroit.

During 1952, 18,500 one-half hour sulfur dioxide readings were obtained and tabulated. Analyses were made of 4,675 samples secured with the Owens Automatic Air Filter.

Light transmission was continuously recorded during 1952. For this report, the data for the period August 7 through September 19, 1952 was tabulated by half hour intervals.

The median weights for total particulate matter ranged from a low of 170.8 at Station 24 (residential) to a high of 401.7 micrograms per cubic meter of air at Station 15 (industrial). By arranging sampling stations according to decreasing median weights, most sampling stations occupied similar positions in 1951 and 1952. Highest median weights were found at sampling stations in relatively close proximity to industrialized areas, while lower median weights were obtained in residential areas quite far removed from industry.

For the nine stations, the difference between the highest and lowest median values was 230.9 micrograms per cubic meter of air, whereas, the range between minimum and maximum values, by station, was considerably greater, being as much as 620 micrograms per cubic meter of air. The concentration fluctuation was greater at any individual station than between the stations. This observation was also noted in the 1951 results.

In general, there was no significant change from 1951 to 1952 in weights of air-borne particulate matter. In 1952, 80.1 percent of the samples were within the range of 0.0 to 400.0 micrograms per cubic meter of air, whereas, 81.7 percent were in that classification in 1951. In 1952, 19.4 percent were from 400.1 to 650.0 micrograms per cubic meter of air, and 16.1 percent were in that range in 1951.

The data revealed that, in general, major high and low values of total particulates occurred on the same dates at all stations. The daily averages of all nine stations for 1951 and 1952 were remarkably similar.

Total particulate matter of the high volume air samples, after being weighed, was analyzed spectrographically to identify twenty-two elements qualitatively and semiquantitatively. Aluminum, iron and silicon were the most predominant, having median values of 3.6, 2.4 and 1.7 micrograms per cubic meter of air, respectively. The median values for vanadium, tungsten, nickel, bismuth, chromium, barium, molybdenum, titanium, tin, copper, manganese, zinc, lead, and magnesium ranged from 0.008 to 0.9 micrograms per cubic meter of air. Antimony, cadmium, cobalt and beryllium were generally either absent or in trace quantities. Like the median total weight values, the median values for the elements remained quite constant for the two years.

Except for three stations, the comparison of the relative standings of stations in terms of total particulate matter to the summation of the ten most prominent elements showed relatively good agreement.

When studying the relationship of the elements in the soil to those in air-borne particulate matter, it was found that with few exceptions, the air-borne particulate matter contained higher concentrations of the elements analyzed than did soil samples. In both air-borne particulate matter and soil samples, calcium, aluminum, iron and silicon composed approximately 90 percent of the weight of the twenty-two elements.

When comparing the total weight of particulate matter of the samples collected on Sundays and Wednesdays, there were appreciably heavier concentrations on Wednesdays. There was, however, little difference in the average total weight of the twenty-two elements between the two days.

A study of the ratio of the weight of the elements analyzed to the total weight of the sample (particulate matter) on days of light and heavy pollution showed that regardless of the variation in weight of sample, the quantities of the elements present were relatively constant. It is therefore apparent that constituents, other than those analyzed, are present in greater quantities when the pollution is high than when the pollution is low; in all probability, these include a substantial amount of organic constituents.

During a period of higher than normal total air pollution which resulted in distressing effects upon the community, none of the individual inorganic elements determined increased sufficiently to be considered a pertinent factor.

Accurate visibility measurements made with the Transmissometer indicated that a relationship existed between transmissivity and pollutants. The average of readings obtained for the period August 7 through September 19, 1952 was 6.5 miles. During a three day temperature inversion higher than normal air pollutants were found, and the light transmission was reduced to an average of 2.3 miles. For the period studied, the light transmission average value for Monday was the greatest, 9.4 miles, with Thursday's average value, 3.8 miles, being the lowest.

Owens Automatic Air Filter data showed similar trends at the two locations sampled. In a residential area, the darkest shading occurred at 5:00 a.m. followed by a rather rapid decrease in color density obtaining a low at 12:00 noon. Samples obtained in the downtown area followed the same general pattern with minimum and maximum density of shade occurring two hours later. These data indicate that there was a probable rhythmic pattern associated with the rise and fall of particulates regardless of sampling location in the Detroit area.

Frequency distribution of the Thomas Autometer sulfur dioxide half hour average readings during 1952 were in remarkably close agreement in all concentration ranges with the data obtained in 1951. The average sulfur dioxide concentration for the year was 0.06 ppm. Each day of the week also showed the same average value.

Monthly average sulfur dioxide concentrations were as follows: January - 0.10; February - 0.08; March - 0.08; April - 0.06; May - 0.05; June - 0.02; July - 0.02; August - 0.03; September - 0.04; November - 0.07; and December - 0.11.

The greatest percentage of peak values of sulfur dioxide occurred between the hours of 12:00 midnight and 3:59 a.m., while the lowest percentage occurred between 4:00 and 7:59 p.m. During 1952, the highest momentary sulfur dioxide concentration was 2.40 ppm which occurred in July.

The sulfur dioxide concentration at Station 11 was much higher during the sampling period of January 11 to 31 than for the period July 25 to August 31, probably indicating that the concentration of sulfur dioxide was more closely related to the time of the year than to our sampling locations.

A meteorological study of 1952 revealed that, in general, it was typical of the climatology of the area. Daily surface weather reports at Detroit City Airport and four radio soundings at Selfridge Field Air Force Base were used as indicators of stability from August 7 through September 19, 1952.

Particulate matter samples collected in Detroit and Windsor were combined and averaged to establish, for meteorological comparisons, a daily pollution level. High pollution periods were concurrent with light winds. Rapid cleaning of the air was associated with increasing wind speed.

The mean daily temperature difference between the surface and 850 millibars was found to be a good index of low level stability. Cold air masses in the Great Lakes Region exhibit greater low level instability than warm air masses. High pollution is associated with high stability and above normal temperatures; low pollution is associated with high instability and cooler temperatures.

The mean total particulate concentration for Detroit-Windsor on a day the predominant wind direction was northeast was 100 micrograms per cubic meter of air, northwest 180, southeast 296 and southwest 271. The lower concentrations obtained when the wind is from the northerly direction may be accounted for, in part, by the greater instability and a predominance of lower than normal temperatures associated with the northeast and northwest winds and that just the reverse conditions are concurrent with the southeast and southwest winds.

Cold frontal passages, in general, cause a reduction in pollution concentration. The effects of rainfall on pollution concentration was indeterminate.

CONCLUSIONS

1. The pollution in Detroit, particularly in a number of areas, is at a sufficiently high level to warrant a study of its detrimental effects upon the community.
2. There has been no significant change in the particulate pollution level of the general atmosphere during the two year period covered by this investigation. Improvements in control of major sources of pollution were either insufficient to be reflected in the measurements or the expansion of the community introduced other sources which served to maintain the pollution level.
3. Dusty playfields, heavily travelled streets, and road construction in the immediate vicinity of the sampling sites had the usual effect on the weight of air pollutants collected.
4. There is a marked diurnal fluctuation of air pollutants; the highest values being obtained at approximately 6:00 a.m.
5. Since the air pollutants rise and fall similarly throughout the area, there does not appear to be a need for meteorological studies on a micro scale, but rather on a scale which would explain the effects of turbulence, lapse rates and inversions, etc., over the area as a whole.
6. The greatest concentration of particulate pollution is in the industrial areas, while lowest concentration is in the residential areas.
7. Particulate pollution in the Detroit-Windsor area was inversely related to the surface wind speed.
8. Particulate pollution was directly related to the stability of the air.
9. Periods of high particulate pollution tended to occur during abnormally warm weather, while periods of low pollution tended to occur during abnormally cool weather.
10. Particulate pollution was highest with south through west winds and lowest with north through east wind flow.

11. Cold frontal passages were an effective mechanism for reducing the levels of particulate pollution.
12. There was no evidence from this study to either support or refute the theory that rainfall alone can effectively reduce particulate pollution.
13. A study of the weights of the elements analyzed to the total weight of each particulate sample, on days of light and heavy pollution, showed that regardless of the variation in weight of sample, the quantities of those elements present were relatively constant.
14. During a period of higher than normal total air pollution which resulted in distressing effects upon the community, none of the inorganic elements analyzed increased sufficiently to be considered an individual pertinent factor.
15. In both air-borne and soil samples, the four elements, calcium, aluminum, iron and silicon, composed approximately 90 percent of the weight of the twenty-two elements analyzed.
16. With few exceptions, air-borne particulate matter contained higher concentrations of the elements analyzed than did surface soil samples.
17. Analyses of ten common elements showed higher median values in samples from industrial areas than in samples from residential areas.
18. None of the elements analyzed in the soil samples could be used as an index to represent the amount of wind-blown surface soil collected in the air samples.
19. Higher concentrations of particulate pollution were found during the middle of the week (Wednesdays) than on Sundays, with little difference in the average total weight of the twenty-two elements between the two days.
20. Since the weight of the twenty-two elements remained quite constant regardless of weight of sample, constituents other than those analyzed are present in greater quantities when pollution is high than when pollution is low; in all probability these are organic constituents and carbon.

21. Median values of the elements determined were quite similar in 1951 and 1952.
22. There is a relationship between light transmissivity of the air and total air pollutants.
23. Average sulfur dioxide concentrations in the summer months are lower than during the winter months. However, these average concentrations, based on data covering over 18,000 samples, are higher than those reported for many American cities. They range from 0.02 to 0.05 ppm in summer to a high of 0.11 ppm in December. Peak concentrations have reached a high of 2.4 ppm.
24. In Detroit it is indicated that there is little, if any, relationship between sulfur dioxide concentrations and collected air-borne particulates.
25. Sulfur dioxide concentrations are probably more closely related to the time of the year than to the locations of our present sampling stations.
26. There was no significant difference in sulfur dioxide concentrations for the years 1951 and 1952.
27. Data collected to date are insufficient to determine the extent of transboundary pollution.

III. PLAN OF STUDY

TECHNICAL ADVISORY BOARD

Following receipt of the air pollution Reference, the International Joint Commission established in April 1949 a board of consultants which subsequently became known as the Technical Advisory Board on Air Pollution. The purpose of this Board is to give technical direction to the field work, to plan the studies on both the Canadian and United States sides of the boundary, to review the findings periodically, to discuss the significance of the data accumulated and to make reports and recommendations to the International Joint Commission.

Members

At the time this report was prepared the Board consisted of:

United States

George D. Clayton, Chairman
Environmental Health Center
U. S. Public Health Service

J. F. Barkley
Chief, Fuels Utilization Branch
U. S. Bureau of Mines

Paul D. Haney
Director of Field Activities
Environmental Health Center
U. S. Public Health Service

Canada

Morris Katz, Chairman
Defence Research Chemical
Laboratories

J. R. Menzies
Chief, Public Health Engr. Div.
Dept. of National Health and Welfare

C. M. Jephcott
Ontario Department of Health

The first meeting of the Technical Board was held in Windsor, Ontario, May 12, 1949. Frequent meetings were held during the formative stages of the study and are now held three times a year.

The Reference outlined to the Technical Board, the scope of the study. It did not, however, specify the area of the investigation with the exception that it should include the entire length of the Detroit River. It was necessary, therefore, at an early meeting of the Board, to define the area of study. After careful deliberation, the Board decided on the boundary as follows: Peche Isle at the north end of the Detroit River to Grosse Ile at the south end, and to extend 15 miles inland on each side of the river.

After careful study of the Reference, the Board established the following five objectives, as well as considered the type of organization necessary to accomplish these objectives. It became apparent very early in the planning of this investigation, that sufficient funds to conduct this study would not be forthcoming from the Governments of the United States and Canada. It was therefore necessary, and the Board also felt desirable, to obtain the cooperation and assistance of those agencies within the community who are responsible for health and welfare of the populace. These agencies included organizations at the local, state, provincial and national levels.

To assist in the planning of the engineering and medical facets of this problem, advisory boards, composed of leaders in their respective fields, have also been organized.

OBJECTIVES

Objective No. 1

Determination of sources, nature and amounts of atmospheric contaminants resulting from combustion of fuels.

Under this objective, a study is being made to determine the amount of pollution from fuel combustion of vessels, railroads, domestic, industrial and automotive sources. The Ringelmann chart was accepted as the standard method of estimating the density of smoke.

Objective No. 2

Determination of sources, nature and amounts of atmospheric contaminants resulting from industrial processes.

To achieve this objective, it will be necessary to obtain mass emission rates from industrial stacks in which toxic materials, and other contaminants are being discharged to the atmosphere.

The Technical Board requested the Division of Industrial Health, Michigan Department of Health, to assist in obtaining data from industry within the study area outside of the Detroit city limits. Within the city limits, the Bureau of Industrial Hygiene, Detroit Department of Health and Bureau of Smoke Inspection and Abatement, Detroit Department of Buildings and Safety Engineering were requested to assist in obtaining such information.

An evaluation of the resources of these groups revealed that they needed assistance in this immense task. It was therefore requested that industries supply data on their own stack emissions. To obtain this end, a meeting was held with representatives of industries, at which time the study was outlined and their cooperation and assistance requested.

At their request, a semester course on stack sampling was established under the auspices of the University of Michigan. Men with considerable experience in this type of work presented eighteen lectures on the various methods commonly in use for the collection and analysis of stack effluents.

Plants inadequately staffed with technical personnel to study their own problems could be assisted by personnel from the state or city organizations.

Objective No. 3.

Determination of effects of meteorological factors on the dissemination and diffusion of atmospheric contaminants.

The Canadian Section of the Technical Board has employed Mr. H. Baynton, meteorologist, who is responsible for the meteorological studies on both sides of the international boundary. Messrs. F. D. White and W. W. Oak of the U. S. Weather Bureau are assisting in this phase of the investigation.

The weather data used for correlation purposes in this report were obtained from the U. S. Weather Bureau.

Objective No. 4

Determination of the effect of the atmospheric contaminants upon (a) health, (b) vegetation, (c) safety, and (d) economy.

HEALTH STUDY

Extensive preliminary work has been in progress since 1950 on the investigation of survey methods and to a lesser degree, in the reviewing of health records. Following this preliminary work, a comprehensive investigation of the effects of atmospheric pollution on health will begin in may 1953. The principal participating agencies in the health study have been the Department of National Health and Welfare of Canada, the United States Public Health Service, Ontario Department of Health, Detroit Department of Health and the Windsor Board of Health.

HEALTH OBJECTIVES

As a means of defining terms of Reference for the health portion of the investigation, certain objectives were established:

- (1) To determine the relationship, if any, of toxic gases or particles to the amount, type, and severity of various acute and chronic diseases in the Detroit-Windsor area.
- (2) To determine the amount of disability in terms of lost time from such illness.
- (3) To evaluate the extent to which chronic cardiovascular or respiratory diseases are aggravated by toxic air pollutants.
- (4) To correlate meteorological data and air pollution with the distribution of illness.

PLAN AND METHODOLOGY

As no measurable relationships have been established between air pollution and health, the most logical plan for the investigation appeared to be the use and evaluation of multiple methods and measurements according to a definite plan. The study and evaluation of methodology was considered of prime importance. It was further agreed that two general approaches would be used:

- (1) The review of existing health data in the Detroit River area, for comparison with other cities, and
- (2) The conducting of a sample morbidity survey in the area to measure and compare the intensity and types of sicknesses and symptoms in well-defined areas of high and low pollution.

As far as possible, both of these will be carried out at the same time.

A REVIEW OF HEALTH DATA IN THE COMMUNITY

A comprehensive analysis of mortality statistics, hospital and medical care records, and industrial and school health records is planned. The objective of this approach is to compare vital statistics and other health records from the Detroit-Windsor area with non-polluted areas and to correlate such statistics with periods of high pollution in the study area. Thus far, only a few preliminary investigations of mortality records have been undertaken. However, these have already produced data which merit careful consideration.

The proposed methodology has been summarized by Clayton^{1/} and Peart^{2/}. The over-all objectives of this approach are (1) to correlate the amount of respiratory and general symptoms and sickness with the increased intensity of air pollution, and (2) to compare the total amount of such symptoms and sickness in areas of high and low pollution. Forms and instructions for use in the morbidity survey have been prepared and are to be evaluated in a pretest involving 150 families in both Detroit and Windsor.

VEGETATION STUDY

The evaluation of the effects of atmospheric contaminants on vegetation was planned to commence in 1953. Consulting services of plant pathologists were solicited to determine which plants are particularly susceptible to certain gases. The species to be included were

dependable annuals known to be injured by gases such as SO_2 , Cl or HF , namely buckwheat, chard, table beets, gladiolus and radish. Through the cooperation of local garden clubs, landscaping organizations, local communities, state college and university groups, plots were to be established throughout the study area containing these selected plants. Periodic inspection of the plots and general vegetation in the area by plant pathologists were to be conducted. A similar procedure was planned for the Canadian side with the same group making the inspections on both sides of the border twice a month during the growing season.

SAFETY STUDY

The effect of atmospheric pollution on safety will be undertaken to determine its relationship to aviation, automotive and pedestrian traffic. Appropriate organizations will be requested to participate in this study which will be designed to determine the relationship of air pollutants to visibility.

ECONOMY STUDY

The evaluation of the effects of air pollution on economy will include corrosion studies on metals, paints, textiles, and building materials. This phase will be conducted with the cooperation of the National Society of Corrosion Engineers and Electro Platers Association and local engineering groups. The initial corrosion studies will be the exposure of test strips of plated and nonplated metals. The studies of paints, textiles and building materials are now being planned.

Objective No. 5

The determination of controls necessary. (a) Cost, and (b) by whom should the cost be borne?

Under the terms of the Reference, this objective applies only to vessels. The Lake Carriers' and Dominion Marine Associations and vessel owners are cooperating in obtaining the information necessary to answer this objective.

In 1952 the Technical Advisory Board initiated a program aimed at eventually reducing vessel smoke emissions to meet the currently accepted ASME Smoke Code. The International Joint Commission realized it was unreasonable to expect the vessel owners to comply with a stringent code immediately. Therefore, the Commission instructed the Technical Advisory Board to prepare yearly objectives which could

reasonably be met by vessels having various types of firing equipment, with the understanding that the objectives would become more restrictive until the final objective has been met.

1952 Smoke Emission Objectives

These objectives are established yearly after consultation with representatives of the Lake Carriers' and Dominion Marine Associations and Cities of Detroit and Windsor. The 1952 Smoke Emission Objectives were:

1. For stoker-equipped coal-fired water-tube boilers, the maximum emission shall be not more than No. 2 Ringelmann for 80 percent of the time, based on a time period of one-half hour, and not more than No. 3 for 20 percent of the time. This means that the production of No. 4 or No. 5 smoke, or more than 6 minutes in any half hour of smoke darker than No. 2, up to and including No. 3, would be declared unreasonable under all ordinary circumstances.
2. For other types of coal-fired equipment, the emission will be considered unreasonable if No. 4 Ringelmann or darker is emitted practically continuously.
3. Oil-fired vessels will be expected ordinarily to stay within the smoke limitations of the Cities of Detroit and Windsor which permit smoke equal to but not darker than No. 2 up to 4 minutes in one-half hour.

The Lake Carriers' and Dominion Marine Associations have been actively supporting this program. In order to inform the ship captains of excessive smoke performance as they pass through the Detroit River, it was planned to contact, via radiotelephone, the objectionable vessel.

Since 1949, when the Canadian Section of the Technical Advisory Board initiated the vessel smoke observation program, continued improvement has been noted. This improvement is largely the result of the aggressive action taken by the Lake Carriers' and Dominion Marine Associations.

INTRODUCTION

The collection of environmental contaminants was begun in the Spring of 1951. The first extensive study was undertaken during the period May 7 to June 17, 1951, to determine (1) qualitatively and quantitatively certain contaminants present in the atmosphere, (2) define areas of high and low pollution for the study of effects of air pollutants upon the community, and (3) the influence of meteorological factors on contamination. The results of this study are reported in the publication "Report on 1951 Environmental Findings" 3.

A second intensive study of air-borne contaminants was conducted during the period August 7 to September 19, 1952. An analysis of the 1951 data made it possible to conduct this survey by utilizing only nine of the thirty-one sampling stations used in the 1951 study. This second sampling period was undertaken to (1) determine the difference in total particulate and sulfur dioxide pollution between the years 1951 and 1952, (2) determine the fluctuation of the elements during the two periods, and (3) obtain additional information on the influence of meteorological factors on dispersion of aerial pollutants.

A high volume air sampler was installed at the same locations in each of the nine sampling areas as were used in the previous study. Samplers were operated on a four day week in order to prevent the additional cost of overtime on the weekends for the city employees. This resulted in the procurement of four or less samples a week from all stations except three which were operated on weekends by members of the U. S. Public Health Service.

In 1951 Dr. H. P. Brinton assisted in the selection of sampling areas. This phase of the study was conducted in the following manner:

SELECTION OF AIR SAMPLING AREAS

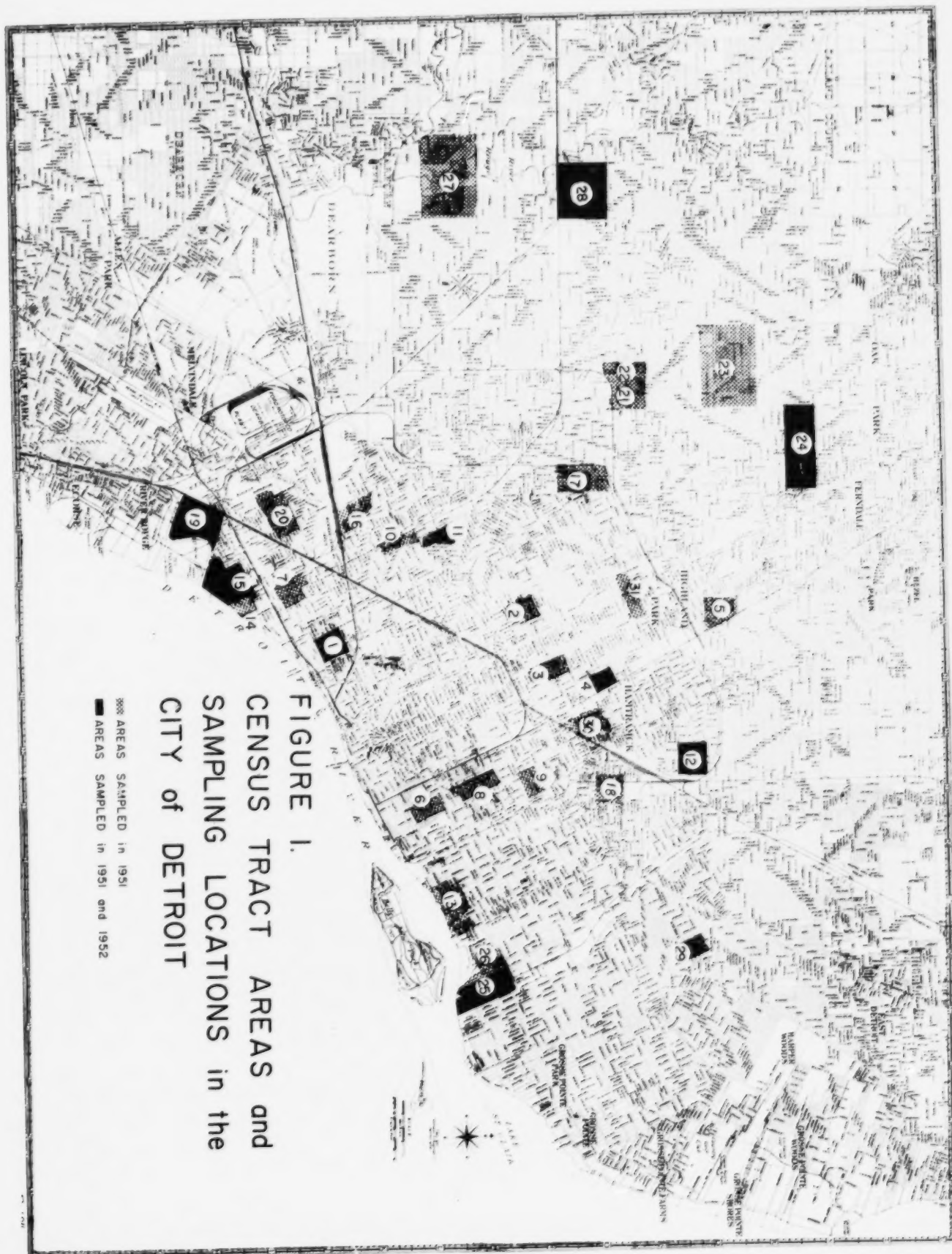
A study was made to choose census tracts in groups with similar human environments, but different degrees of air pollution. To obtain a rough estimate of the relative amount of air pollution in different areas, maps, prepared in the office of the city assessor, showed the boundaries of all industrial properties in the City of Detroit. These maps were divided among the district air pollution inspectors and each of the inspectors evaluated the plants in his district on the basis of their estimated contribution of air pollution. He classified each plant

according to the probable type of emission. Substances emitted were grouped into the following classes: solids active, solids inactive, and gases active. Each class was further divided into heavy or minor pollution, making a total of six classes. A sheet attached to each map showed identifying number, name of company, and pollution code. This information was transferred, using appropriate symbols, to eleven census tract maps covering the entire City of Detroit. It was thus possible to readily visualize sources of atmospheric contamination and the probable types of pollutants in the areas.

Much information by census tract was found to be available and a preliminary estimate was made of the socio-economic status of each of the 369 census tracts in the City of Detroit. Among the more important data used were the 1950 preliminary count of population, average population density per square mile, public assistance cases per 1,000 population, economic rating (based on income and rent in 1946) percentage of population nonwhite, percentage of population foreign born, median years of schooling, percentage of homes with mechanical refrigeration, and percentage of homes owner occupied. Maps with tracts shaded in different degrees were prepared for most of the above items, so that the variation from tract to tract could be visualized.

From these maps it was possible to prepare a tract map showing the entire city divided into the following areas: (1) colored, (2) white middle class, and (3) white lower class. From each of the eleven air pollution spot maps a group of tracts representing low pollution were selected. These tracts were then arranged according to socio-economic status. Care was taken to see that tracts in the same socio-economic group were alike in all respects except for pollution. If any one of the several socio-economic factors differed widely, the tract was excluded from consideration. Where several adjacent tracts appeared to be similar, both as to air pollution and socio-economic status, the central one was selected to represent the whole area. It was thus possible to reduce the number of tracts which would need to be visited in the field.

Fifty-two tracts were selected for actual visitation. These were distributed over the entire city, but were not equally spaced because of the greater variability of potential air pollution in certain districts. As might be imagined, areas of high pollution were usually those represented by lower than average socio-economic status.



The lowest socio-economic status of every tract with light air pollution was included. Through this course of visits and inspection, certain socially demoralized high pollution tracts near the center of the city were eliminated. The populations of such areas is so unstable that reliable sickness data would not be obtainable. On the other hand, the best socio-economic status of high pollution tracts were also eliminated, because past statistical experience has proven a lack of necessary cooperation.

Field investigations of the selected tracts reduced the number to be included in the sample, but increased the number of socio-economic groups. It was decided after observation that tracts should be classed as Negro with low, medium, or high income; white high middle or low middle class; white high lower or low lower class. Air pollution as estimated by visual inspection was light, moderate, moderate to heavy, heavy or very heavy. In addition to twenty-six census tracts located in Detroit, one tract was selected in Hamtramck and one in Highland Park, making a total of twenty-eight tracts to be studied.

In 1951, one high volume air sampler was installed in each of these tracts. In three of the tracts the peculiar location, distribution and size of the industries made it advisable to select two sampling points. There was thus a total of thirty-one sampling stations for this period. With the exception of the above three tracts, each sampling point was located as close to the geographic center of the tract as was feasible and consistent with the location of sources of pollution. Mobile Thomas Autometers, automatic sulfur dioxide analyzing and recording devices, were placed at each of twelve of these stations for a one week run during the six weeks' period.

DESCRIPTION OF SAMPLING AREAS

In 1952, nine of the thirty-one sampling stations^{3/} were again utilized. These were Sampling Stations Numbers 1, 4, 11, 12, 15, 19, 24, 25, and 28.

In order to more clearly describe the physical properties of these stations, the area within a one mile radius of the stations has been divided into four quadrants by lines drawn through the sampling point; in most instances, from north to south and from east to west. A description of potential air pollution sources by quadrant is given.

Sampling Station Number 1 was located in a dirty unpaved alley between 22nd and 23rd Streets about two hundred feet north of Porter. The entrance to the Ambassador Bridge was about five hundred feet from the sampling point and the Detroit River was about three-quarters of a mile to the south. The immediate surroundings were residential, with mostly two story frame homes occupied by white families in a low socio-economic bracket.

AREA 1 was approximately half industrial and half residential. The major portion of the industries were close to the sampling point, while the principal residential area was about one half mile away. Among the industries were three foundries, four large rendering plants, and an asphalt plant.

AREA 2 was slightly more industrialized, with most of the industry concentrated near the waterfront. The immediate surroundings of the sampling station were residential. Among the major sources of pollution in the area were six foundries, an abrasives company, a gas producing plant, and a series of railroad tracks lining the waterfront.

AREA 3 was primarily residential, with most of the industry located about one half mile and farther from the sampling point. Included in the industries were seven foundries, a municipal incinerator and three chemical plants.

AREA 4 was about one-fourth residential. The remaining three-fourths of the area was comprised of an automobile plant, four foundries, an oil pumping station, a porcelain enameling plant, a paint manufacturer, as well as several railroad tracks.

Sampling Station Number 4 was located on Hindle about one hundred feet south of Kenwood. At the sampling location, Hindle was heavily travelled, paved, and very dirty. All the streets in the vicinity were also dirty. Directly opposite the sampler were a school and large unpaved playfield. All the homes in the vicinity of the station were frame and occupied by low income Negro families.

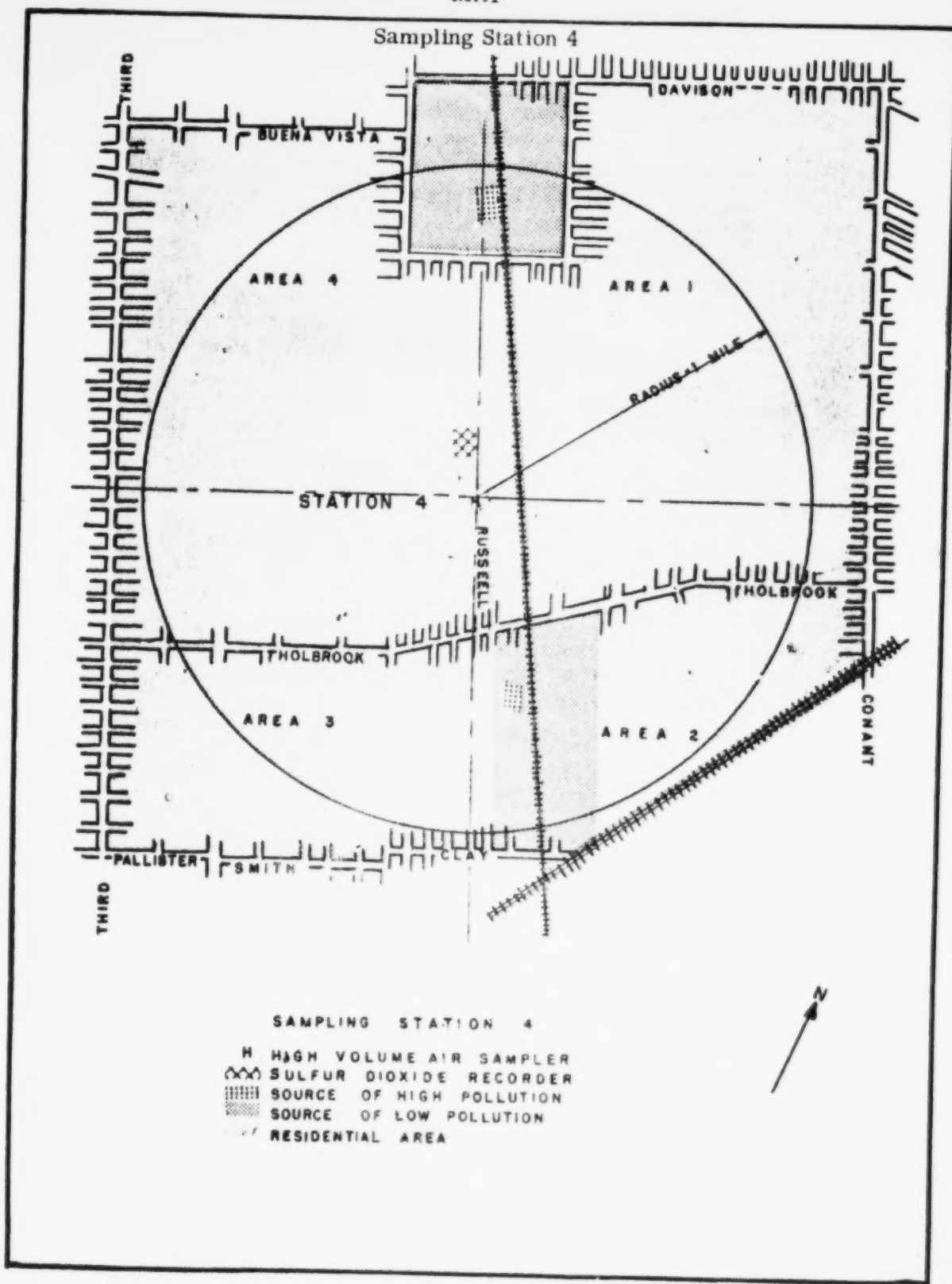
AREA 1 was mostly residential, with industry located more than a mile to the east. The major industries were a paint manufacturing plant, foundries and metal fabricating plants.

AREA 2 was about three-fourths industrial, with most of the residential area west of the railroad tracks which bisected the area. The industries were foundries, automobile parts and body plants, metal fabricating plants, and several coal yards.

AREA 3 was residential with small retail stores along Woodward Avenue.

AREA 4 was almost entirely residential, with some industry concentrated along the railroad tracks. About one mile to the north was an Automobile plant.

MAP



Sampling Station Number 11 was located in the paved alley between Milford and Cobb Place, about fifty feet west of Begole Street. The immediate surroundings were residential, mostly two story frame dwellings occupied by white families in the lower socio-economic brackets.

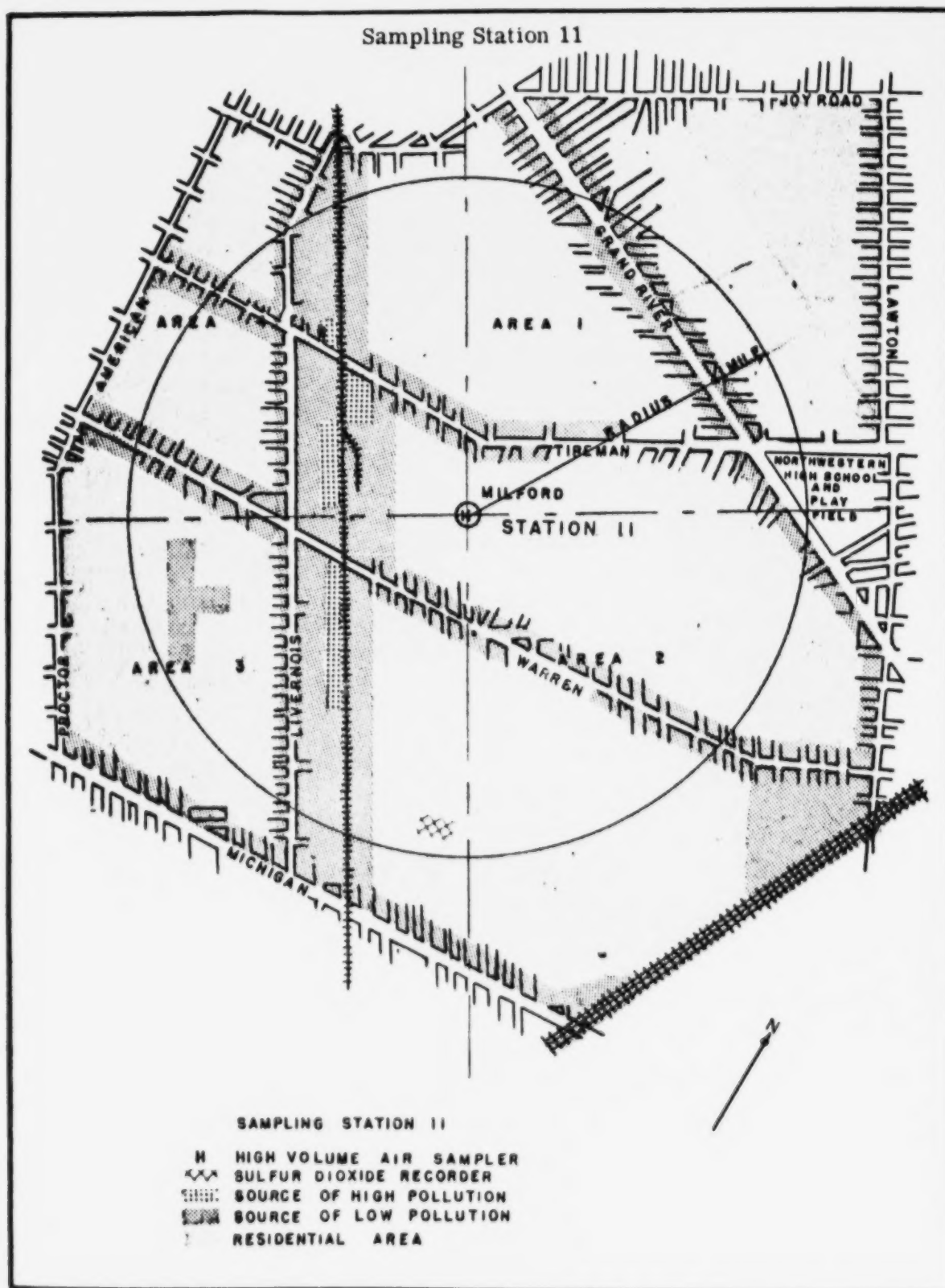
AREA 1 had as its chief sources of pollution, the small retail stores and heavy traffic on Grand Boulevard, Grand River, and Dexter. There were several schools in the area, one of which was about seventy-five to one hundred feet from the sampler. The area was almost entirely residential.

AREA 2 was residential, with the major sources of pollution more than a mile to the south of sampling station.

AREA 3 was approximately three-fourths residential. Industry which was located near the railroad tracks, consisted of several coal yards, foundries and a large metal fabricating plant. Livernois and Warren Avenues were two important heavily travelled streets in the area.

AREA 4 was the most heavily industrialized of the areas. In this area, in addition to others, were located an automobile plant, gas manufacturing plant, foundries and chemical companies. Tireman and Livernois Avenues were two of the major traffic arteries in this area.

MAP



Sampling Station Number 12 was located in the dirty, unpaved alley between Desner and Luce, about one hundred feet east of Buffalo. The area was residential with most of the industry more than one-fourth of a mile away. The houses were two story frame, occupied by white families in a high-lower class status.

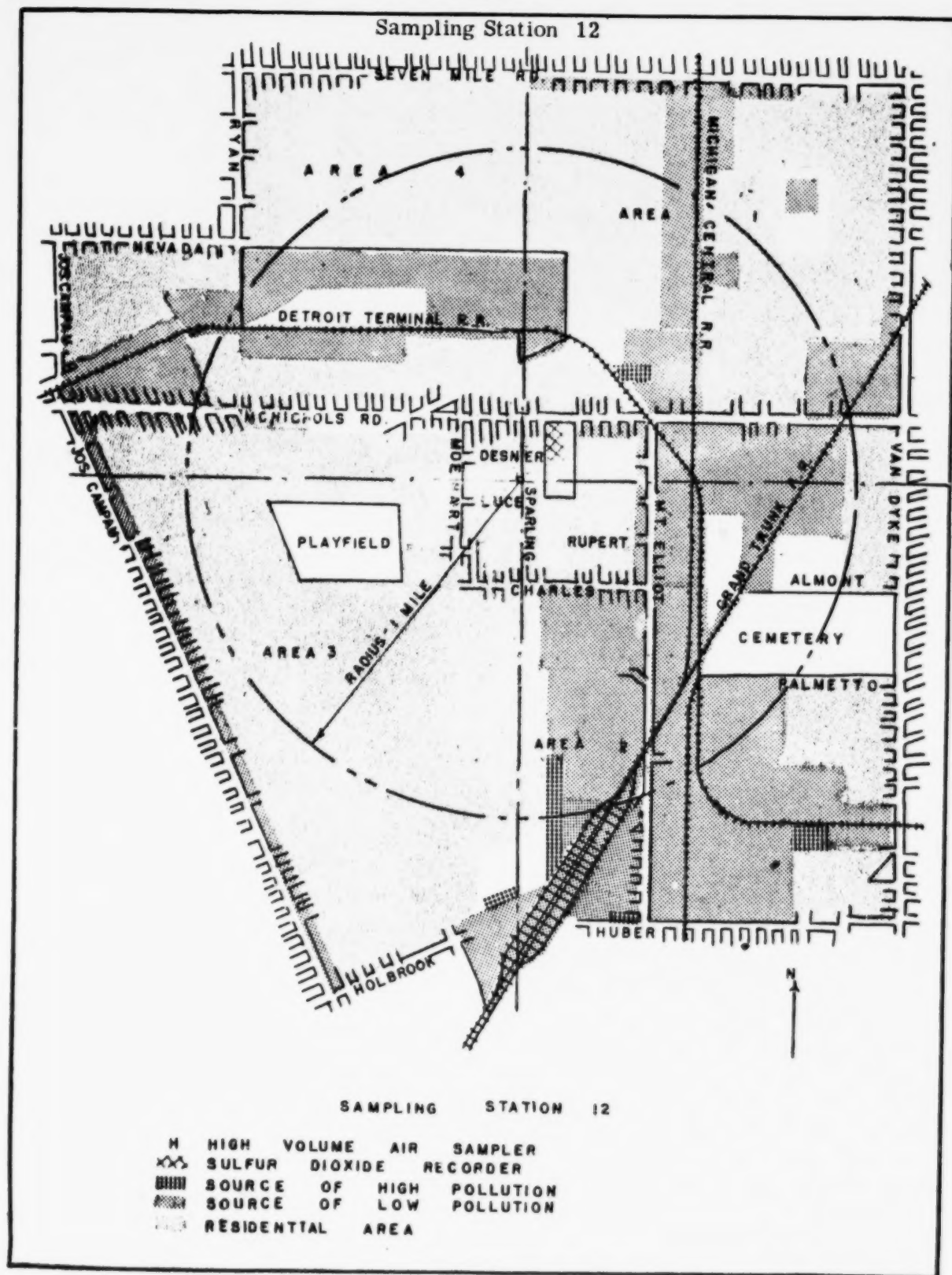
AREA 1 was about one-third industrial and the remainder was either residential or open fields. Industry was located east of Mt. Elliott and north of McNichols Road. Among the industries were coal and lumber yards, four metal fabricating plants, and several smaller manufacturing establishments.

AREA 2 was slightly more than half industrial, with most plants east of Mt. Elliott and south of Charles. Many of the industries, however, such as the several cartage companies, two automobile plants, two foundries, and an oil refining plant had large open areas within their boundaries. A heavy concentration of railroads was found slightly more than a mile to the south of this area.

AREA 3 was mostly residential. There were, however, four foundries within the area. There was also a heating plant for a housing project located about one-fourth of a mile from the station.

AREA 4 had most of its industry concentrated just south of Nevada Avenue. Industry comprised about 30 percent of the area and included a foundry, a chemical plant, a paint and varnish factory, and several asphalt and concrete block plants, as well as numerous metal fabricating plants. Many of the streets north of Nevada were unpaved and dirty.

MAP



Sampling Station Number 15 was located on the north side of Gould Street half way between Harrington and Green. The immediate vicinity was clean and well kept and probably contributed little or nothing to the pollution found at this station. The streets and alleys were paved and clean.

The description of the four areas for this station is the same as Station 19 and is given under Station 19.

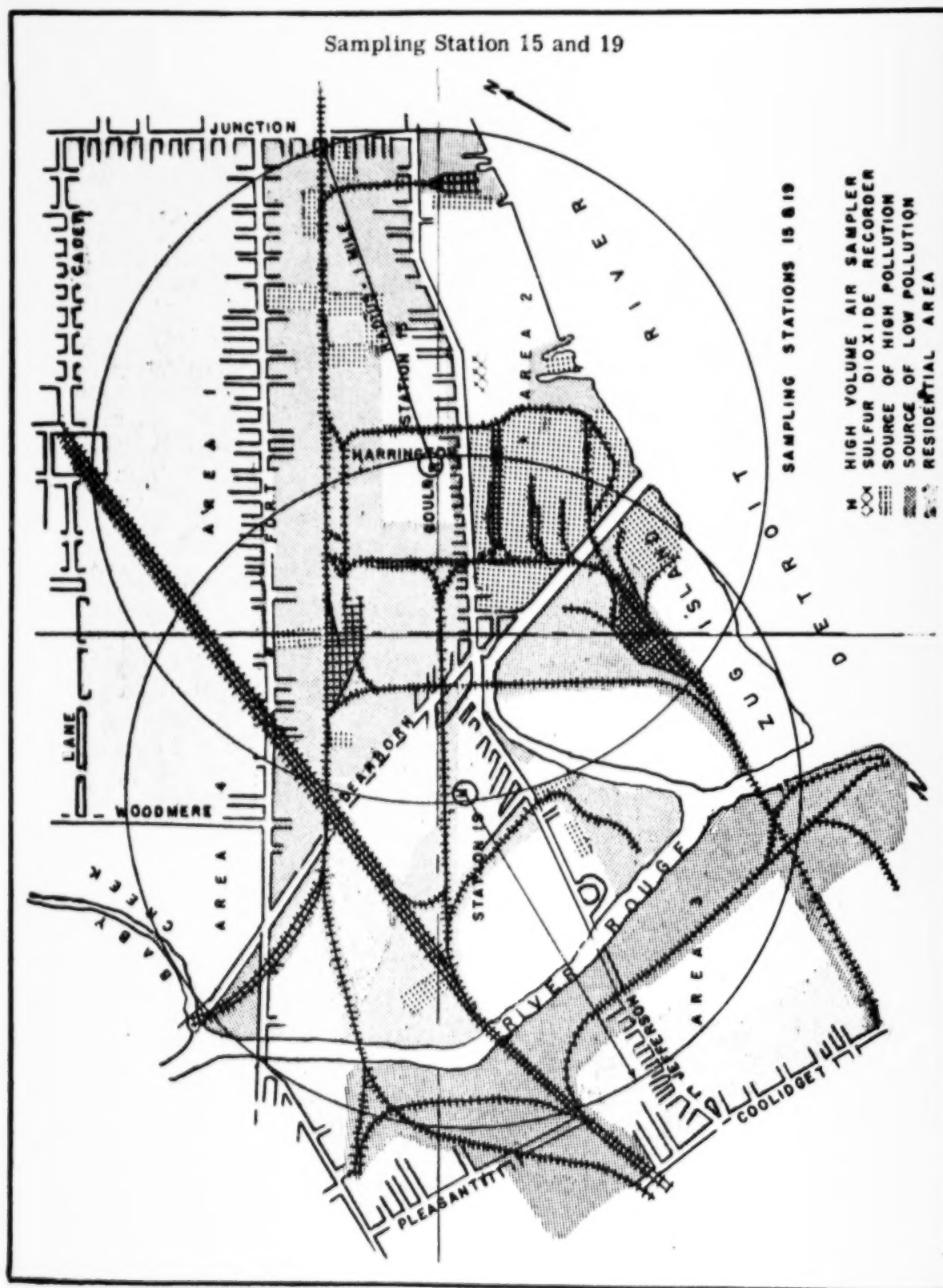
Sampling Station Number 19 was located in the alley north of Portland about fifty feet east of the intersection of the alley with Beaumont. The alley was dirty, unpaved, and littered with rubbish. Some pollution may have been added in the immediate vicinity of the sampler from the trash burners and dirty conditions generally existing.

AREA 1 was approximately one-half industrial with the residential area being north of Fort Street. In the area were six brass foundries, twelve steel and iron foundries, nine automobile parts and accessory plants, six coal and fuel yards and a large chemical plant, several trucking companies and numerous small retail stores and fabricating plants. Large open fields surrounded many of the plants.

AREA 2 was entirely industrial, except for Ft. Wayne Military Reservation, it contained two large chemical plants, a large power plant, a brass foundry and many metal fabricating shops, coke oven operations and blast furnaces.

AREA 3 contained many of the heavy industries of the city, along with a rather large area of unsettled or uninhabited sections. Only about 15 percent of the area was residential. The area contained cement and gypsum plants, a large pulp and paper factory, an acid plant, and a sewage treatment unit in addition to the smaller factors. A large steel plant which was located approximately one and one-half miles from the sampling station probably affected the study area.

AREA 4 was approximately 40 percent residential. It included, among others, twelve coal and fuel yards, a large power plant, three chemical plants, a large automobile plant and numerous foundries, which were about one and one-half miles from the sampling station, undoubtedly affected the study area. The houses in the residential area were one and two family frame houses occupied by whites in a low income and low socio-economic group.



Sampling Station Number 24 was located in the unpaved alley between Indiana and Wisconsin, about thirty feet south of Chippewa. The area was completely residential, there being no industry within a mile radius except for small retail stores along Livernois, one mile to the east, and Eight Mile Road, about half a mile north. The immediate area was occupied by low income Negro families who lived in frame houses and shacks, or converted Quonset huts. Streets in the immediate vicinity were paved.

AREAS 1, 2, 3 and 4. About three hundred feet from the station was a school. Sources of pollution in the four areas included schools, a hospital (area 3), a housing project heating plant, and small metal fabricating plants.

Sampling Station Number 25 was located in the paved alley east of Clairpointe Street and about fifty feet north of the intersection with Freud. The station was adjacent to an automobile factory.

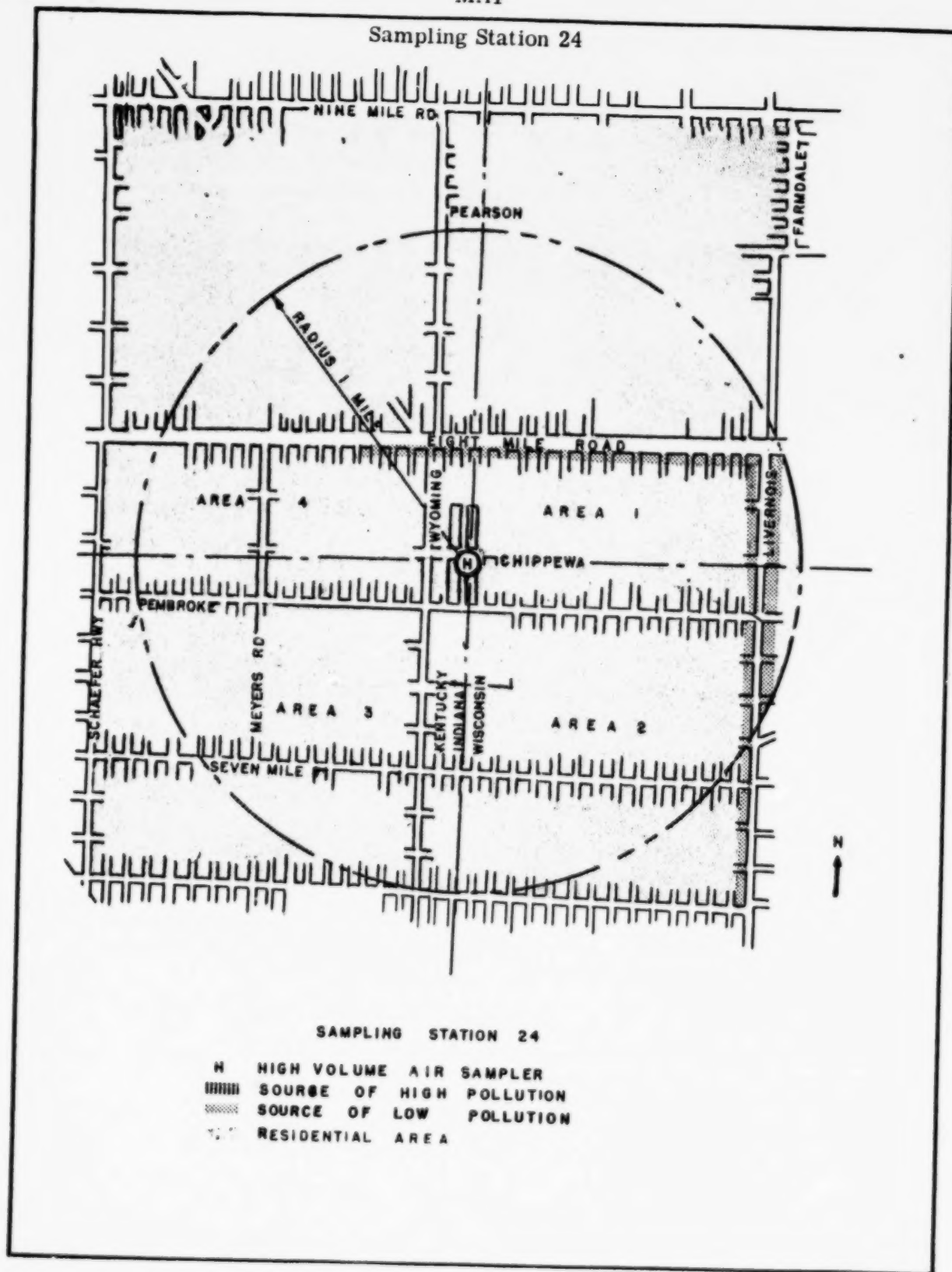
AREA 1 was approximately 75 percent residential and 25 percent industrial and contained three automobile factories, coal yards, six automobile parts factories, in addition to numerous small tool and metal fabricating plants. Dwellings were of a one family type occupied by both whites and colored in the lower middle economic bracket.

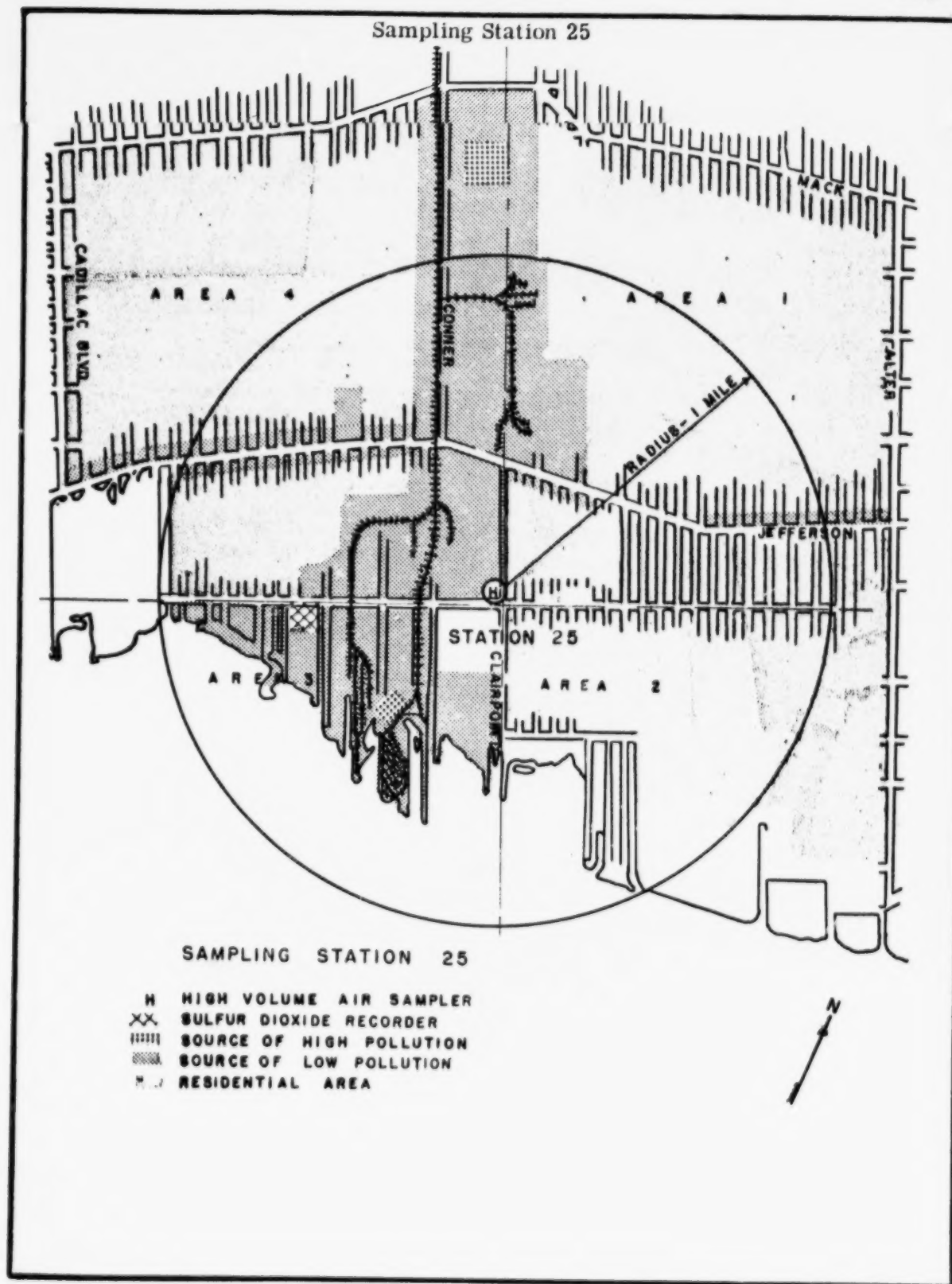
AREA 2 was residential with the houses being mostly one family type occupied by lower middle class whites.

AREA 3 was almost entirely industrialized. Industry included two metal products plants, a door factory, electrical power generating plant, Detroit City Waterworks, automobile factory, cement plant, foundries, and numerous small manufacturing plants in addition to loading docks along the Detroit River and large open fields.

AREA 4 was approximately 60 percent residential. The industries included foundries and large automobile parts plants.

MAP





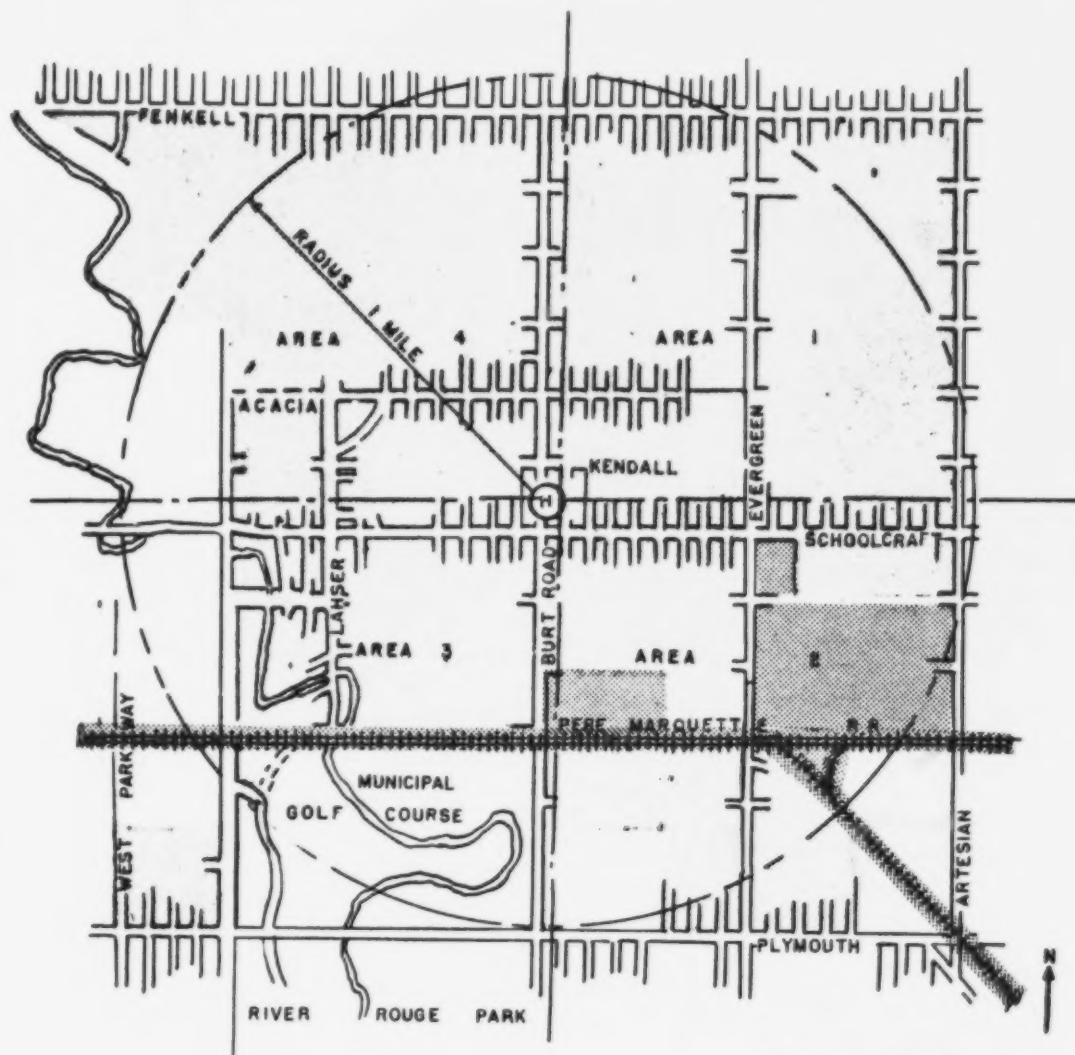
Sampling Station Number 28 was located in the alley between Burt Road and Pierson, about two hundred feet north of Kendall. The alley was unpaved and infrequently travelled.

AREAS 1 and 4 contained no industry.

AREA 2 was the only one of the four areas which contained industry. There were a small foundry, eleven tool and metal fabricating shops, a sand and gravel and ready mix cement plant, as well as several smaller manufacturing establishments. The industries were located between Evergreen and Artesian, about a half mile from the station just north of the railroad tracks.

AREA 3 was also entirely residential except for River Rouge Park and golf course. The area was bisected by a railroad track.

Sampling Station 28



SAMPLING STATION 28

M HIGH VOLUME AIR SAMPLER
 SOURCE OF HIGH POLLUTION
 SOURCE OF LOW POLLUTION
 RESIDENTIAL AREA

V. SAMPLING EQUIPMENT

HIGH VOLUME AIR SAMPLER

The High Volume Air Sampler was used to collect particulate matter. The essential parts of the sampler as shown in Figure 2, consisted of an Electrolux blower mounted in an aluminum housing, a filter paper retaining ring located on the intake side of the blower and a U-tube manometer located on the exhaust side. The manometer was used for determining pressure differential between the inside of the housing and the atmosphere. The manometer was subsequently calibrated with a dry gas meter to obtain the air flow in cubic feet per minute.

A bucket type handle was provided for carrying the sampler. When the unit was in operation it was held in place by an aluminum rod $3/4$ inch in diameter and 6 inches long, located on the under side of the frame.

In the field, our experience with these instruments indicated that after one thousand hours of continuous operation, the blower unit was worn to such a degree as to require its replacement, thus, making the maintenance of these samplers excessive.

At most locations the sampler was mounted on a utility pole at a height of ten feet above the ground. Drop cords from the overhead power lines and crossarms were installed gratis by the Detroit Edison Company. A metal shield was attached to protect the sample and the instrument from rain.

An accordion pleated filter paper, presenting a large surface, was used for the entrainment of the air-borne particulates. The rate of flow through the average clean filter was approximately sixty-five cubic feet per minute. As the sample was being collected, the air flow rate decreased as a result of the resistance of the particulates on the filter. In areas of heavy pollution, at the end of a twenty-four hour sampling period, the flow rate often would be reduced to approximately twenty-five cubic feet of air per minute.

Figure 2.
High Volume Air Sampler and Accordion
Pleated Filter



In operation, the filter was replaced every twenty-four hours. Manometer readings were taken before stopping the pump for removal of the filter, and immediately after a clean filter was inserted. To increase accuracy in the reading, instructions were given to stop and start the instrument three different times (allowing a minimum of one minute of operation to insure the liquid in the manometer to reach equilibrium) and a reading taken in each instance. The average of the three readings was then recorded.

A data record sheet as shown in Figure 3, was developed on which was listed the sample number, sampling location, filter paper number, name of the investigator, date and time started, reading, date and time stopped, reading, total air sampled, remarks of unusual occurrences in the sampling area, and weather data.

Calculations of the total air volume were based on the assumption that there was a constant and uniform increase in resistance, with a corresponding straight line decrease in the volume of air passing through the filter. Accordingly, the air volumes corresponding to the start and stop values were averaged and multiplied by the total number of minutes the sampler was in operation. It was realized that this straight line relationship was not completely accurate, however, it was believed that the error was not sufficiently great to warrant the cost of installing recording devices on each of the samplers.

THOMAS AUTOMETER

The Thomas Autometer (Figure 4) was used for continuous evaluation and recording the "sulfur dioxide" content of the air. The instrument was developed by Dr. M. D. Thomas and his associates of the American Smelting and Refining Company.^{4/}

The instrument measures small concentrations of sulfur dioxide and other soluble contaminants in the air which changes electrical conductivity of the absorbing solution. The change in conductivity is

Data Record Sheet

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
PUBLIC HEALTH SERVICE ENVIRONMENTAL HEALTH CENTER
International Air Pollution Study

(1) Atmospheric Filter Paper Sampling Data

Sampling Location _____ Filter Paper No. _____
Name of Investigator _____
Time and Date Started _____ Reading _____
Time and Date Stopped _____ Reading _____
Total Air Volume Sampled, Cu.Ft. _____ Cu. M. _____
C.F.M. _____ REMARKS _____

(2) Weather Data

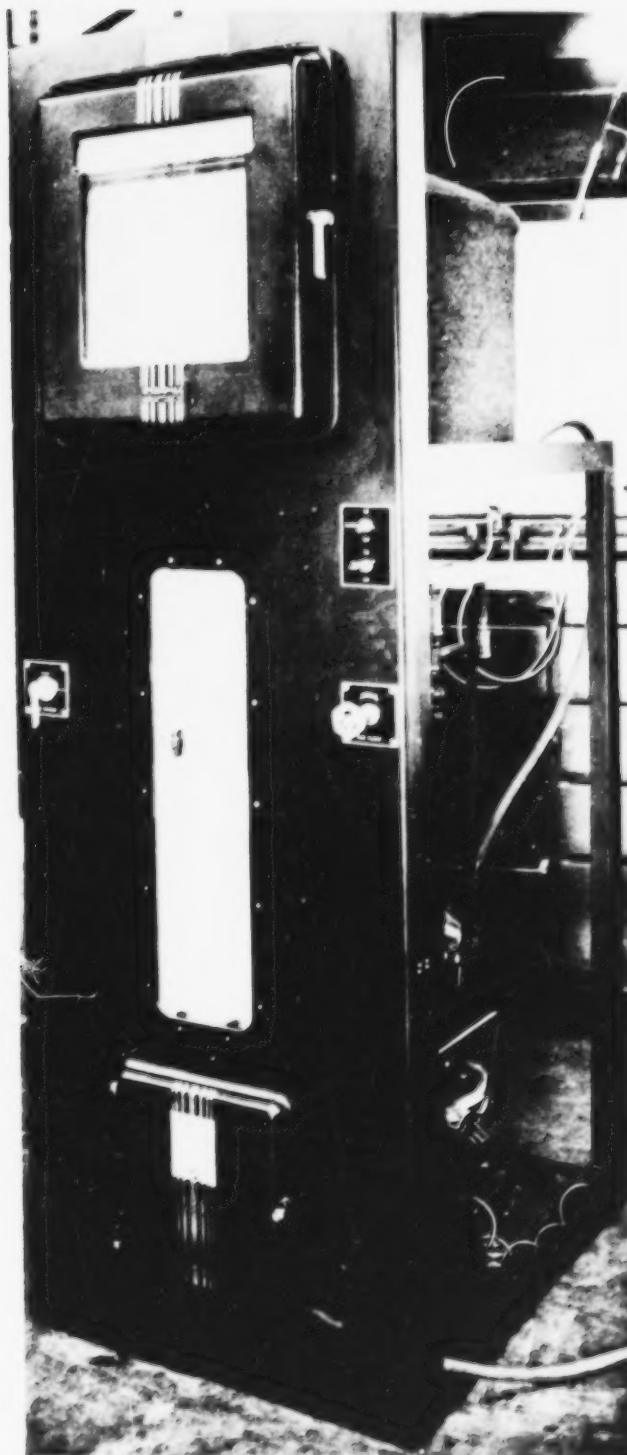
Time	12M - 6 a.m.	6 a.m. - 12N	12N - 6 p.m.	6 p.m. - 12M
RAIN				
SNOW				
SLEET				
FOGGY				
CLEAR				

(3) Analytical Data

Weight After _____ Weight Before _____
Weight of Sample _____ Wt. micrograms/cubic meter _____
RESULTS _____

Figure 4.

Thomas Autometer



recorded as parts per million (ppm) of sulfur dioxide. A measured quantity of air flows countercurrent to a measured quantity of absorbing solution inside a uniformly heated cabinet. The absorbing solution consists of 2 to 4 x 10⁻³M hydrogen peroxide in 5 x 10⁻⁵N sulfuric acid. The sulfur dioxide in the air is absorbed and oxidized, increasing the conductivity of the solution.

The autometer was calibrated^{5/} after every move during the first few months of operation. However, since it was soon found that no changes occurred, it was then calibrated approximately once a month. The zero was reset, if necessary, each time solution was added or at each inspection. The continuous recording cell of the instrument was zeroed by adjusting the air inlet valve so that the air passed through the sulfur dioxide absorber tube. When more accurate calibration was indicated, a solution of known concentration was made up with sulfuric acid and used to check the reading of each of the cells. While any concentration within the limits of the instrument may be permissible, a concentration of three parts per million was commonly used.

To more readily cover the study area of approximately five hundred square miles, the Autometer was installed in a mobile laboratory. A complete discussion of the mobile laboratory and the operation problems of the Thomas Autometer are discussed in a paper by Giever^{6/}.

OWENS AUTOMATIC AIR FILTER

The Owens Automatic Air Filter (Figure 5) is an instrument used in obtaining frequent intermittent automatic records of the soiling effects of air pollutants. Its construction and method of operation has been fully described by Shaw and Owens^{7/}.

In this instrument a two liter volume of air is passed through a 1/8 inch diameter opening near the outer portion of a white circular filter paper seven inches in diameter. The impurities present in the air are measured by the depth of the shade produced on the filter paper. The sampling period is approximately four minutes and from four to six samples are obtained each hour. A sample disk with pollution records, as shown in Figure 6, is rotated by a clock and pulley arrangement and makes a complete revolution in twenty-four hours.

As the instrument sampled frequently during the twenty-four hour period, a record was obtained on the variation of the pollution at different times of day and night, as well as the changes from day to day.

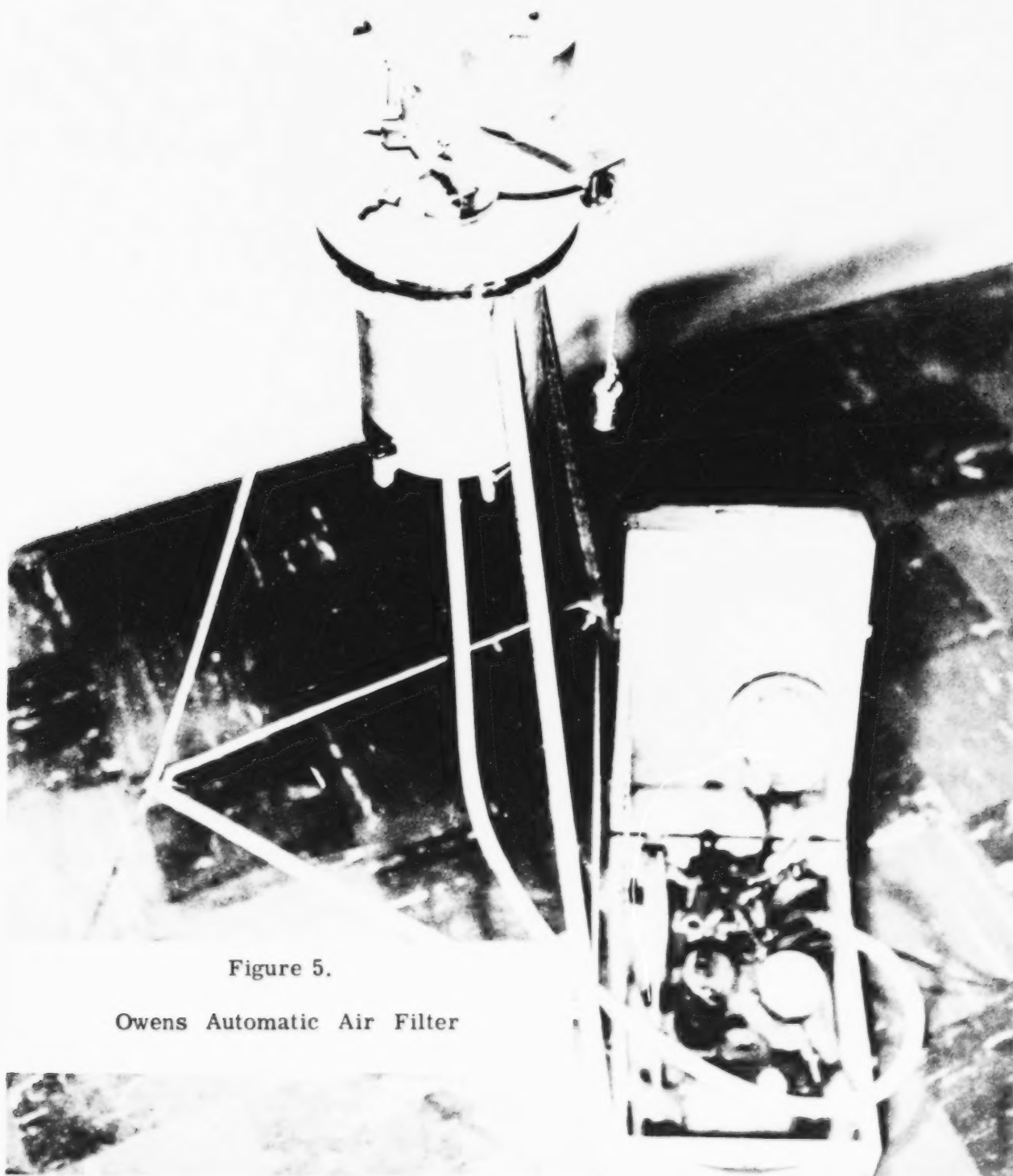
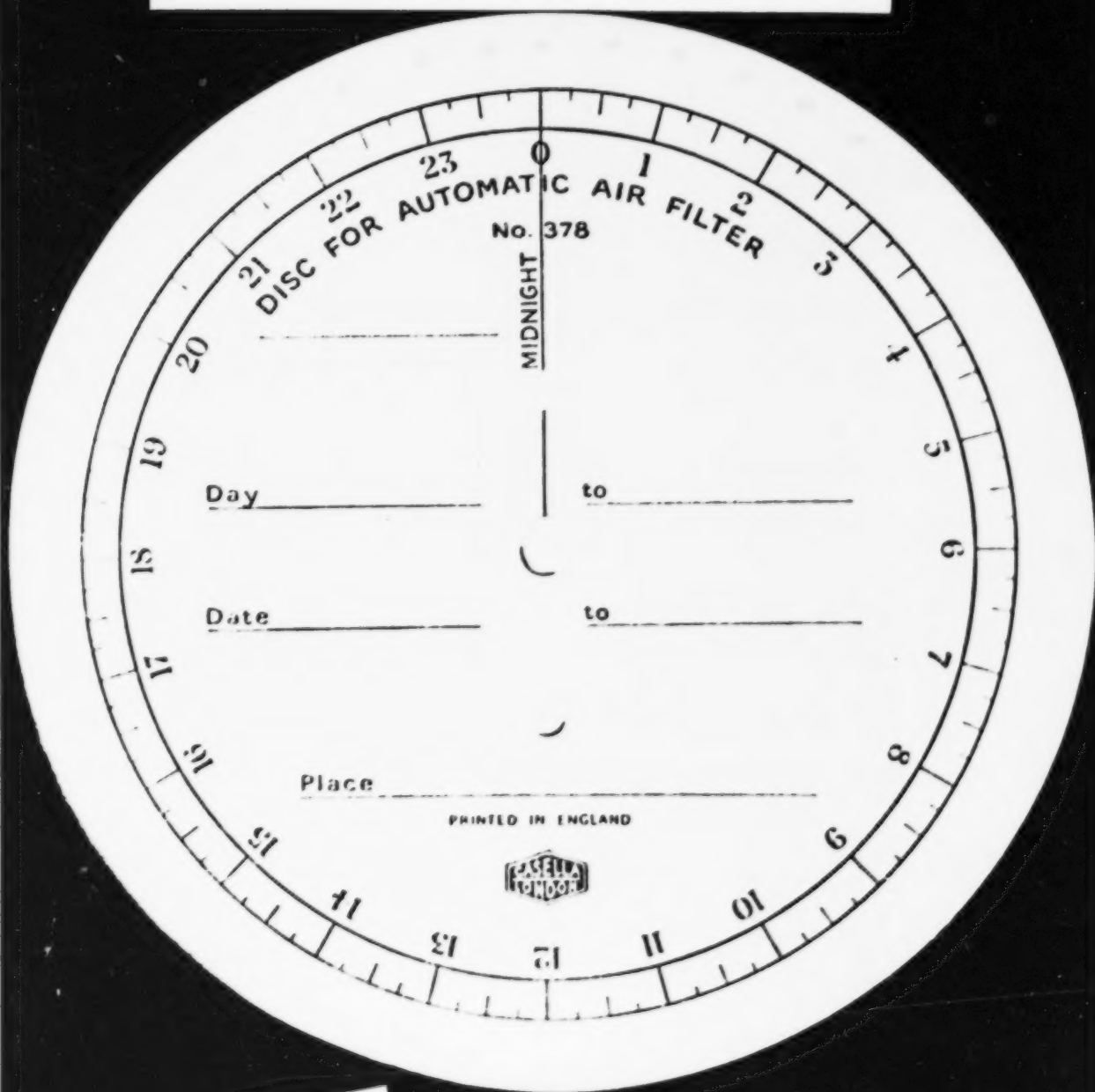


Figure 5.

Owens Automatic Air Filter

Figure 6
Sample Disk



Reproduced from
best available copy.



Figure 7

Standard Scale of Shades

Reproduced from
best available copy.

SCALE OF SHADES FOR AUTOMATIC FILTER

Pass the record under the scale of shades; then by examining the record through the hole in the shade, holding in a diffused light, the shade which matches the record may be found.

UNIT OF SHADES .. 0.54 lb. per million cubic yards.
0.32 milligrammes per cubic metre.

Shade No. A

Shade No. A B C D E F G H I J K L

50/11

The degree of pollution represented by the discoloration of the spot was determined by visually comparing its grayness with that of a standard scale of shades. (Figure 7) Public Health Bulletin No. 224⁸/ describes the standard scale of shades as follows:

"The standard scale of shades consists of a row of ten rectangles, each half an inch square, varying in grayness from a very light gray, marked "1", to a very dark gray, marked "20". The ten shades are numbered 1, 2, 3, 4, 6, 8, 10, 12, 15, and 20, respectively. They are made by applying a standard wash of lampblack to white paper as many times as the number of the shade. The density of each shade is therefore a multiple of unit shade. Each shade has a hole $\frac{1}{8}$ inch in diameter punched in its center, and a spot on the disk is compared with a standard shade by inserting it under the hole. In comparing spots on the disk with the standard shades, some difficulty was experienced in finding exact matches. It was decided to use the number of the shade that most nearly matched the sample spot, calling a shade lying between 0 and 0.5, 0; between 0.6 and 1.5, 1; and between 1.6 and 2.5, 2 etc. This method of determining the shade of a spot introduced little difficulty for higher pollutions, but when the pollution was very low, brought the average pollution to a point somewhat below its actual value. Except in the case of very low pollutions, however, the error thus introduced was seldom of any significance."

The Owens Automatic Filters used in this investigation were the same as those used in the study by the Public Health Service in 1931 and 1932. The instruments therefore, were quite old and considerable difficulty was encountered with the proper flow of water and its subsequent discharge. The obtaining of water at the location of these instruments was also difficult. For these reasons the instruments were equipped with an electrical pump and automatic timer. These changes made a marked improvement over the original design of the instrument and in no way affected the frequency of sampling or the volume of air drawn through the filter disk.

TRANSMISSOMETER

Visibility measurements were made by the Transmissometer (Figure 8), and electronic instrument, developed by the National Bureau of Standards, which measures accurately and continuously the light transmission between two fixed points. The instrument, as described by C. A. Douglas⁹/ consists of a light source, a phototube receiver, amplifier and an indicator. The amount of light falling on

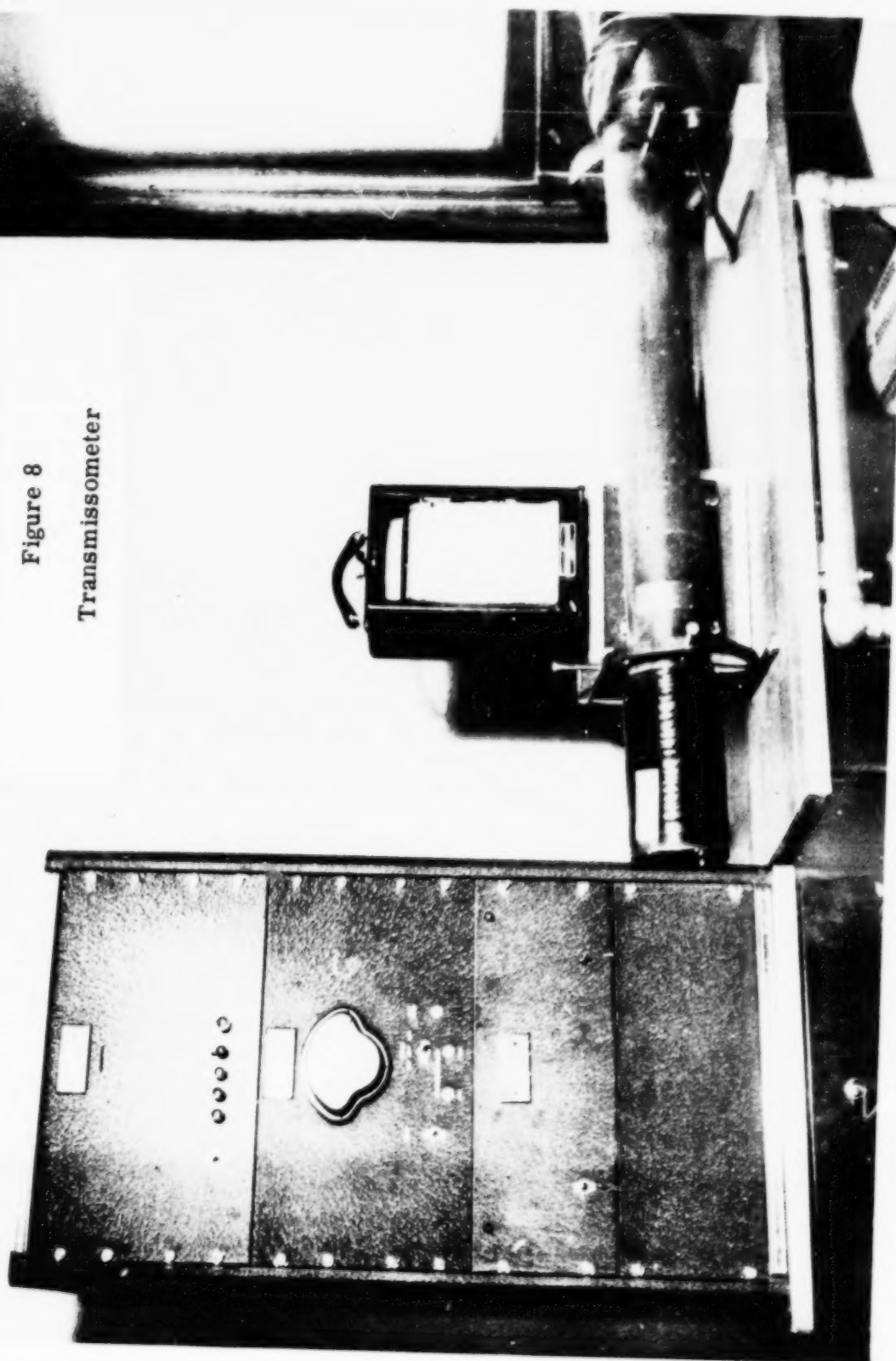


Figure 8
Transmissometer

the receiver from the constant intensity light source is determined by the transmissivity of the atmosphere. The light source consists of a three hundred and fifty thousand candle power, six volt, sealed reflector lamp, the intensity of which is controlled by a voltage regulating transformer. The Transmissometer receiver consists of a lens diaphragm, a photopulse unit and an amplifier. Light from the source focused by the lens on a pinhole in the diaphragm falls on the phototube receiver and there generates pulses whose frequency is directly proportional to the intensity of the light incident on the phototube. These pulses are amplified and transmitted over signal line to the indicator and to the Esterline Angus type of recorder which makes a permanent record of the readings.

VI. LABORATORY TECHNIQUES

TOTAL PARTICULATE MATTER

As stated previously, the high volume air sampler with accordian pleated filters was used for the collection of particulate matter. The filter used was a type-S unimpregnated filter secured from the Mine Safety Appliance Company. The filters were about 3-3/4 inches, (9.5 cm.) in diameter and 1 inch (2.5 cm.) high and were pleated in concentric rings. Silverman and Viles^{10/} reported collection efficiencies of 68 percent for tobacco smoke and 99 percent for certain dusts and fumes when collected on these filters at a flow rate of 60 cubic feet (1.7 cu.m.) per minute.

The filters were prepared and the samples subsequently weighed in the Industrial Hygiene Laboratory of the Detroit Department of Health. Spectrographic analyses were made in the U. S. Public Health Service laboratories of the Division of Occupational Health, Cincinnati, Ohio.

The methods of weighing and spectrographic analysis described herewith are an abstract of a paper presented by Keenan and Byers^{11/}.

Weighing Procedure

Silverman and Viles reported that the filter weights were reproducible to ± 0.5 mg. To accomplish this they dried the filter at 110°C. for sixteen hours, and then weighed it at 111°C. in a specially constructed balance having one pan suspended in the oven. The precision was greater than needed for this work and the weighing was too time-consuming, so it was necessary to develop a more rapid weighing procedure with some sacrifice of accuracy.

After drying in the oven, filters exposed to the atmosphere gained moisture much too rapidly for weighing. Covered ointment cans 3-3/4 inches (9.5 cm.) in diameter and 1-1/4 inch (3 cm.) high were procured in which to place the filters for weighing. In the covered cans the filters could be weighed to the nearest milligram without difficulty. These cans also served as shipping containers for the filters before and after sampling.

The filters were placed in uncovered cans which were then stacked in a drying oven at 110°C. Upon removal from the oven the cans were immediately covered and transferred to a desiccator to cool. After cooling for thirty minutes, they were weighed.

Experimental work with the filters showed that when heated at 110°C . the filters lost weight rapidly at first, then more slowly until after sixteen to twenty-four hours a relatively constant weight (± 3 mg.) was obtained. Fairly reproducible results were obtainable with any given drying period. In one experiment a set of filters was dried for two hours, cooled, and weighed, then allowed to stand over water for several hours. The drying and weighing were then repeated. This cycle was repeated a number of times, and the greatest difference from highest to lowest value for any filter was 20 mg. In consideration of the size of the samples to be collected, such a variation was considered permissible. A group of filters dried and reweighed after several months, varied less than 20 mg. from their original weight.

In the actual conduct of the study, filters sent into the field were dried for two hours at 110°C . and weighed as described. Upon return of the filter, the filter plus sample was dried and weighed in the same manner. The difference was taken as the weight of the sample. The samples weighed from 0.2 to more than 1.5 gm., with an average of 0.7 gm. A variation of 20 mg. was therefore a maximum of 10 percent in error and less than 5 percent for most of the samples. Of course, any material volatilized at 110°C . was driven off and not included. This was not considered serious for the metallic constituents.

Sample Recovery

According to Silverman and Viles, the type-S filter could be ashed without serious contamination of the sample. While this was true for industrial exposures such as they were considering, it did not hold true for the atmospheric pollution samples. Several metals were present in the filter in larger quantities than were later found in the pollution samples. Therefore, ashing of the filters was not feasible. Washing of the filters with water or acids also removed excessive quantities of metals from the filter. Washing of the filters with alcohol was tried, and only calcium gave a detectable blank by this procedure.

A standard washing procedure was established. The filter was placed in 250 ml. of redistilled 95 percent ethyl alcohol in a one liter beaker. It was thoroughly agitated by rotary and vertical motion, after which it was immersed, removed and squeezed-out about thirty times. Then the filter was transferred to another beaker with 250 ml. of fresh alcohol, and the procedure was repeated. A rubber glove was worn while performing this operation; the gloved hand was rinsed with alcohol from the wash bottle between successive filters. The filters were air-dried and saved for subsequent weighing. The alcohol washings

were combined, evaporated, and wet-ashed for analysis, as will be described later.

Twenty unused filters selected from several batches were dried sixteen hours and weighed; then they were washed by the foregoing procedure. The washed filters were air-dried for two to five days before again being dried sixteen hours at 110°C. and reweighed. The filters lost an average of 41 mg. in weight. When the alcohol washings were evaporated to dryness in a weighed pyrex dish, the residues averaged 39 mg. per filter.

It was found that this air-drying and prolonged heating were necessary to remove the alcohol from the filters. Apparently some chemical or surface activity tended to retain alcohol in the filters. Fortunately, the weight of alcohol retained did not vary greatly between filters. It was thus possible to establish a correction factor for the calculation of the weight of sample removed by the washing procedure. Twenty-nine samples were selected at random and washed by the standardized procedure. The alcohol washings were evaporated in weighed 125-ml., pyrex Phillips beakers. The residue was dried at 110°C. and weighed. This residue weight was checked against the weight of sample removed from the filter as calculated from the corrected final weight of the filter. The average difference was 23 mg. The portions of the samples removed from these filters varied from 60 percent with an average of 72 percent.

Semiquantitative Spectrographic Method

It was anticipated that a considerable number of the metallic constituents would be present in the particulate material samples in extremely low or trace concentrations. Since it would have been extremely difficult to effect clean-cut chemical separations of most of these trace elements, it was decided to develop and to apply a rapid spectrographic procedure for this work. Furthermore, time did not permit the development of an individual spectrographic quantitative method for each of the twenty-two elements subsequently estimated in each sample. Therefore, a semiquantitative procedure which was based upon the visual comparison of the sample spectrograms and the spectrograms prepared from a series of standard solutions, was developed. This comparison of specific line spectra was made in a Jarrell-Ash, Model 200, comparator-densitometer; this instrument facilitated the comparing of spectrograms on standard plates with those on the sample plates by projecting them into juxtaposition and magnifying the projected spectral line images.

In order to prepare a series of standard solutions whose spectrograms would contain the individual line spectra of all of the desired elements over the proper concentration ranges, the first few samples were subjected to a qualitative spectrographic analysis. These analyses gave an idea not only of which elements were apt to be present in subsequent samples but also of their relative quantities. By means of this information the possible concentration ranges for each of the twenty-four different elements was calculated. The upper limit of each range was doubled in the case of certain elements, such as aluminum, iron, and silicon, to ensure sufficiently wide ranges for all samples. The initial standard solution was prepared from A.C.S. grade salts of the twenty-four elements, and eight dilutions of this initial solution were prepared after subjecting the latter to the same wet-ashing procedure to be applied to the samples.

Preparation of Sample Spectrograms

As described previously, the samples were removed from the filters by agitation in redistilled alcohol. The alcohol suspensions were evaporated just to dryness, wet-ashed with a mixture of concentrated nitric and sulfuric acids, then treated with equal volumes of concentrated hydrochloric acid and water. A portion of the sample ash was insoluble. However, all samples were made up to a volume of 10 ml. in a volumetric flask, mixed thoroughly, and the insoluble material suspended by shaking immediately prior to the removal of the portion taken for spectrographic exposure. An indication that a fairly representative portion of the insoluble material was transferred to the electrode was obtained by the agreement of results of silicon determinations by both spectrographic and chemical methods on duplicate portions of the sample samples.

A micropipette assembly was used to load all electrodes. Spectroscopically pure electrodes were used for the exposures in all regions of the spectrum except that in which beryllium and cadmium were read. The loaded electrodes were dried at 105°C. for one hour, then exposed in the 220-volt direct current arc source of a large Littrow spectrograph with quartz optics. Exposures in three spectral regions were required to cover the 2,200 to 4,600 Å. region. The exposure periods and the slit widths were fixed for the specific regions. Eastman III-0 plates were used for the 2,250-2,850 and 2,500-3,200 regions, III-F plates were used for the 3,200-4,600 region. Plates were developed and fixed at 68°F. Twenty-three sample spectrograms were recorded on each plate. After washing for thirty minutes, the plates were air-dried and read in the comparator-densitometer.

A dozen samples which had been analyzed by this semiquantitative spectrographic method were selected at random for chemical analysis in order to evaluate the accuracy of the spectrographic procedure. Since specific methods exist for the separation and estimation of iron and lead and since iron was usually a major and lead a minor constituent, it was deemed desirable to determine chemically these two elements and compare the results with the spectrographic results. Iron was separated by a thiocyanate-ether extraction at the optimum pH (slightly less than 1). A weak nitric acid solution was added to the extract and the ether partially evaporated. More nitric acid was added, and finally the resulting aqueous suspension was wet-ashed. The white residue was dissolved in a predetermined quantity of nitric acid and hot water, diluted to yield the optimum pH, and a portion taken for thiocyanate estimation in Nessler tubes.

The aqueous portions remaining after the removal of iron were wet-ashed with nitric acid. The lead was extracted by a dithizone procedure and the quantity of lead estimated by chromate titration.

VII. RESULTS OF 1952

ENVIRONMENTAL INVESTIGATION

TOTAL PARTICULATE MATTER

The method of selection of sampling sites, the instruments and analytical methods used have been discussed previously in this report. The first extensive study of the atmosphere was undertaken during the period May 7, through June 17, 1951, when samples for particulate matter were collected continuously at thirty-one selected stations. During August 7, through September 19, 1952, the atmosphere was again extensively studied at which time samples were taken at nine of the sampling stations used in the first study. The Detroit Edison Company materially aided by installing samplers and supplying electric power at each of the stations in 1951 and again in 1952. Personnel from Detroit Smoke Abatement Bureau also assisted by changing the high volume filters.

Median Values

Table 1 shows the median, maximum and minimum values obtained by station, during the sampling periods August 7, to September 19, 1952 and May 7, to June 17, 1951. The stations were given a position based on decreasing 1952 median values. Also presented is the corresponding position for each station based on 1951 median values.

During 1952, Station 15 had the highest median value as well as the highest maximum value, while Station 24 had the lowest median value but not the lowest minimum or maximum values.

Three of the five stations showing highest median values were near the riverfront. Median values were lowest for Stations 24 and 28 located in the residential areas.

The spread between the highest median value, Station 15, and the lowest median value, Station 24, was 230.9 micrograms per cubic meter of air or a 2.3 fold increase. The range between minimum and maximum by station was much greater, i.e., Station 15, 8.7 times; Station 12, 19.7 times. As noted in the 1951 results, the concentration fluctuation was greater at any individual station than between the stations.

Table 1 shows the close relationship between values obtained in the study periods in 1951 and 1952, even though these sets of data are for different months of the year.

TABLE 1. Median, maximum and minimum values (in micrograms per cubic meter of air) for total particulate matter at nine stations for the periods August 7 through September 19, 1952 and May 7 through June 17, 1951. The stations are arranged in descending order based on 1952 median values.

August 7 - Sept. 19, 1952					May 7 - June 17, 1951			
Station	Position	Med.	Min.	Max.	Position	Med.	Min.	Max.
15	1	401.7	82.1	719.5	1	357.1	121.0	873.2
19	2	382.0	133.3	647.4	3	342.8	109.2	712.6
4	3	360.4	171.2	565.1	2	344.2	114.0	736.8
11	4	277.0	62.0	467.9	4	281.5	99.1	640.6
1	5	268.7	112.6	529.7	6	265.6	124.0	548.8
12	6	192.7	33.1	652.5	8	198.0	57.8	428.6
25	7	189.2	99.8	586.0	5	275.9	80.6	1008.8
28	8	181.2	33.1	507.1	9	164.6	30.7	359.4
24	9	170.8	52.7	544.7	7	211.4	42.7	600.7

Station 15 ranked highest in median value in each study, whereas Station 19 ranked second highest in median value in 1952 and third in 1951, with approximately 40 micrograms per cubic meter of air increase. The minimum value at Station 19 was 24 micrograms per cubic meter of air greater than in 1951, while the maximum value was about 75 micrograms per cubic meter of air less than in 1951.

Station 4 ranked third in 1952 and second in 1951. The median value for 1952 was 16.2 micrograms per cubic meter of air greater than for 1951. For 1952, the minimum at Station 4 was somewhat greater and the maximum somewhat less than in 1951.

Station 11 maintained fourth ranking in both studies and had approximately the same median value although both maximum and minimum were lower in 1952.

Station 1 ranked fifth in 1952 and sixth in 1951 with median, maximum and minimum values for both studies remarkably similar.

Station 12 ranked sixth in 1952 and eighth in 1951. Median values were nearly identical, but there was a rather large difference in maximum values for the two periods.

Station 25 ranked seventh in 1952 with a median value of 189.2 micrograms per cubic meter of air as compared to fifth in 1951 with a median value of 275.9. At this station the greatest variation was found in median values. During the 1951 sampling period a main thoroughfare was being resurfaced in the area. This work was completed before the start of the 1952 sampling period. As there was no appreciable change in residential and industrial activities, it is concluded that the high values found in 1951 were, in the main, the result of street resurfacing.

Station 24 ranked ninth in median value in 1952 against seventh in 1951. There was approximately a 20 percent decrease between the two periods. It is interesting to note in the 1951 report, that the high median value obtained at this station could probably be accounted for by the large playground located near the station. During the 1951 sampling period, a large number of children played on the grounds as it was during the school year. However, in 1952 this was not the case, as it was between school years. Therefore, the decrease in median values obtained at this station may be in part accounted for by the lack of activity on the dirt school grounds.

Station 28 which ranked eighth in 1952 showed a median value very similar to that obtained in 1951 when it ranked ninth. Minimum values found were quite similar but a much higher maximum value occurred in 1952.

In general, the gravimetric data from stations studied in 1951 were in close agreement with the 1952 data. The four stations with the highest median values were common to both studies, with the positions of Stations 4 and 19 interchanged. Most of the stations showed a higher median value in 1952 than in 1951. However, higher maximum values were found at most of the stations in 1951. The data shows that no significant change in weights of air-borne particulate matter occurred between the 1951 and 1952 sampling periods, thus indicating that concentrations of air-borne particulates in Detroit are relatively constant from one year to the next.

Frequency Distribution

Table 2 presents the distribution of the frequency of total weights of samples collected at nine stations during the period August 7, through September 19, 1952. As may be seen from this table, the majority of the sample weights were more than 100 micrograms per cubic meter of air, and less than 450.

The total number of samples collected at the nine stations ranged from 19 to 38. Stations 12, 24, and 28 were operated seven days a week, whereas the other six stations were operated only four and five days a week.

Table 3 shows the frequency distribution by percentage of the total weight of air samples by station. At station 1, 80.9 percent of the samples were found to be within the range of 100.1 to 400.0 micrograms per cubic meter of air in 1952, as compared to 87.0 percent in the same weight range in 1951.

At Station 4 it will be noted that all samples were within the range of 150.1 to 600.0 micrograms per cubic meter of air in 1952, with 90.4 percent being less than 500.1. There was a somewhat greater dispersion in weights at this station in 1951, the range being from 100.1 to 750.0 micrograms per cubic meter of air, with only 75.7 percent of the samples within the range of 100.1 to 500.0.

At Station 11 all samples were within the range of 50.0 to 500.0, with the most samples, 22.8 percent, in the 350.1 to 400.0 micrograms per cubic meter of air range. In 1951 at this same station 95.2 percent

TABLE 2. Distribution frequency of total weights of air samples collected at nine sampling stations in the Detroit area during August 7 through September 19, 1952

August 7 through September 19, 1952									
Weights ^{1/}	Sampling Stations								
	1	4	11	12	15	19	24	25	28
0.0 - 50.0	-	-	-	1	-	-	-	-	1
50.1 - 100.0	-	-	2	6	1	-	7	1	6
100.1 - 150.0	2	-	4	7	-	2	7	2	6
150.1 - 200.0	3	4	1	6	1	1	6	8	9
200.1 - 250.0	2	2	2	4	2	1	3	3	5
250.1 - 300.0	6	1	3	5	3	3	2	1	5
300.1 - 350.0	3	3	1	2	1	3	8	-	3
350.1 - 400.0	1	3	5	4	2	4	3	1	-
400.1 - 450.0	1	3	2	1	6	5	-	-	-
450.1 - 500.0	1	3	2	-	-	1	1	-	-
500.1 - 550.0	2	1	-	-	1	3	2	2	1
550.1 - 600.0	-	1	-	1	1	-	-	1	-
600.1 - 650.0	-	-	-	-	2	2	-	-	-
650.1 - 700.0	-	-	-	1	-	-	-	-	-
700.1 - 750.0	-	-	-	-	1	-	-	-	-
Total number of samples	21	21	22	38	21	25	39	19	36

^{1/} Weights expressed in micrograms per cubic meter of air.

TABLE 3. Distribution frequency (in percentage) of total weights of air samples collected at 9 sampling stations in the Detroit area August 7 - September 19, 1952 and May 7 - June 17, 1951

Weights ^{1/}	August 7 - September 19, 1952								
	Sampling Station								
	1	4	11	12	15	19	24	25	28
0.0 - 50.0	-	-	-	2.6	-	-	-	-	2.8
50.1 - 100.0	-	-	9.1	15.8	4.8	-	17.9	5.3	16.7
100.1 - 150.0	9.5	-	18.2	18.4	-	8.0	17.9	10.5	16.7
150.1 - 200.0	14.3	19.0	4.5	15.8	4.8	4.0	15.5	42.1	25.0
200.1 - 250.0	9.5	9.4	9.1	10.5	9.5	4.0	7.7	15.8	13.9
250.1 - 300.0	28.5	4.8	13.6	13.3	14.3	12.0	5.1	5.3	13.9
300.1 - 350.0	14.3	14.3	4.5	5.3	4.8	12.0	20.5	-	8.3
350.1 - 400.0	4.8	14.3	22.8	10.5	9.5	16.0	7.7	5.3	-
400.1 - 450.0	4.8	14.3	9.1	2.6	28.4	20.0	-	-	-
450.1 - 500.0	4.8	14.3	9.1	-	-	4.0	2.6	-	-
500.1 - 550.0	9.5	4.8	-	-	4.8	12.0	5.1	10.5	2.8
550.1 - 600.0	-	4.8	-	2.6	4.8	-	-	5.3	-
600.1 - 650.0	-	-	-	-	9.5	8.0	-	-	-
650.1 - 700.0	-	-	-	2.6	-	-	-	-	-
700.1 - 750.0	-	-	-	-	4.8	-	-	-	-
Total number of samples	21	21	22	38	21	25	39	19	36
Weights ^{1/}	May 7 - June 17, 1951								
	Sampling station								
	1	4	11	12	15	19	24	25	28
0.0 - 50.0	-	-	-	-	-	-	4.9	-	4.8
50.1 - 100.0	-	-	2.4	15.8	-	-	12.2	5.7	9.5
100.1 - 150.0	5.0	2.4	7.0	15.8	4.8	2.5	14.6	8.5	26.2
150.1 - 200.0	20.5	7.3	16.7	21.1	9.5	7.5	14.6	25.7	26.2
200.1 - 250.0	17.9	19.5	11.9	21.1	14.3	20.0	26.8	2.9	19.0
250.1 - 300.0	23.2	9.8	14.3	13.2	7.0	12.5	17.0	17.0	11.9
300.1 - 350.0	7.7	12.2	14.3	5.2	14.3	15.0	2.5	8.5	-
350.1 - 400.0	12.8	7.3	16.7	5.2	11.9	12.5	4.9	11.4	2.4
400.1 - 450.0	2.6	17.2	9.5	2.6	11.9	12.5	-	2.9	-
450.1 - 500.0	7.7	2.4	2.4	-	2.4	5.0	-	2.9	-
500.1 - 550.0	2.6	7.3	2.4	-	4.8	10.0	-	2.9	-
550.1 - 600.0	-	7.3	-	-	9.5	-	-	2.9	-
600.1 - 650.0	-	2.4	2.4	-	2.4	-	2.5	2.9	-
650.1 - 700.0	-	-	-	-	2.4	-	-	-	-
700.1 - 750.0	-	4.9	-	-	-	2.5	-	-	-
750.1 - 800.0	-	-	-	-	-	-	-	-	-
800.1 - 850.0	-	-	-	-	-	-	-	-	-
850.1 - 900.0	-	-	-	-	4.8	-	-	-	-
900.1 - 950.0	-	-	-	-	-	-	-	-	-
950.1 - 1000.0	-	-	-	-	-	-	-	2.9	-
1000.1 - 1050.0	-	-	-	-	-	-	-	2.9	-
Total number of samples	39	41	42	38	42	40	41	35	42

^{1/} Weight expressed in micrograms per cubic meter of air

of the samples were within the range of 50.1 to 500.0, with only two samples in higher ranges. The distribution in the 150.1 to 400.0 range was approximately the same in 1951, with variations of only 4.8 percent between largest and smallest number of samples in each range.

At Station 12, 63.1 percent of the samples were less than 250.1 micrograms per cubic meter of air in 1952, all but two samples were within the range of less than 450.1. In 1951 all samples were less than 450.0 and 73.8 percent were less than 250.1 micrograms per cubic meter of air. Distribution of weights was in general quite similar for the two sampling periods.

At Station 15, only 47.7 percent of the samples were within the weight range of less than 400.1 micrograms per cubic meter of air, 28.4 percent were 400.1 to 450.0, and 23.9 percent from 500.1 to 750.0 micrograms per cubic meter of air in 1952. In 1951, 73.7 percent of the samples were less than 450.1 as compared to 76.1 percent in this same range in 1952.

At Station 19, 60 percent of the samples were within the range of 250.1 to 450.0 in 1952. In 1951, 30 percent of the samples were less than 250.1 micrograms per cubic meter of air, 52.5 percent were within 250.1 to 450.0, and 17.5 percent were greater. The greater percentage of weights were within similar ranges for both years but the percentage above and below that majority were reversed from 1952 over 1951.

At Station 24 in 1952, 84.6 percent of the samples were less than 350.1 micrograms per cubic meter of air as compared to 92.6 percent in that same range in 1951. Although a greater number of samples were in the lower ranges in 1951, the median value at this station was somewhat lower in the 1952 study.

In 1952, 57.9 percent of the samples at Station 25 were less than 200.1 micrograms per cubic meter of air, while in the previous study only 39.9 percent were within that weight range. The presence of samples in the 950.1 to 1050.0 range in 1951 presented a somewhat different pattern of sample weight distribution than in 1952, where no samples were more than 600.0 micrograms per cubic meter of air.

At Station 28 in 1952, all samples but one were in the range of 0.0 to 350.0 micrograms per cubic meter of air as compared, in 1951, to all samples but one in the 0.0 to 300.0 range.

In 1952 only 0.8 percent of the samples were less than 50.0 micrograms per cubic meter of air and only 0.4 percent were in excess of 650.0. In 1951, 2.2 percent of the samples were more than 650.0 micrograms per cubic meter of air.

Table 4 summarizes the frequency distribution of the total weights of the samples collected during the sampling periods 1952 and 1951 and shows with few exceptions, the remarkable consistency of the total particulates in the Detroit area from one year to another.

TABLE 4. Summary of frequency distribution of all samples from nine stations for the sampling periods 1952 and 1951

Weights in micro-grams per cubic meter of air	P E R C E N T A G E	
	1952	1951
0.0 - 400.0	80.1	81.7
400.1 - 650.0	19.4	16.1
> 650.0	0.4	2.2

Daily Variations

Figures 9 through 17 graphically present the relationship of the average daily total weight of all stations for 1952 and 1951 to the 1952 total weights obtained at individual stations.

In these figures the days are numbered 1 through 44. For the 1952 data, the dates are from August 7 through September 19, i.e., Day 1 refers to August 7 and Day 44 refers to September 19. The 1951 data is for the period May 7 through June 17. Therefore Day 1 refers to May 7, 1951 and Day 42 refers to June 17, 1951.

It may be observed that the daily fluctuation of weights obtained at each station were quite consistent to the average of all nine stations and in only minor instances were there notable variations. In general, major high and low values occurred on the same dates at all stations.

The presence of the plotted average for these same nine stations in 1951 served to illustrate the remarkable similarity in the daily range between the 1951 and 1952 averages. For obvious reasons, this similarity in oscillations will be of assistance in the research program of evaluating the effects of air pollution on the community.

The policy of operating the samplers only four days each week was unsatisfactory as may be seen by the meager daily data obtained at some stations.

The data available for Station 1 (Figure 9) showed that the daily weights followed closely the trend of the average for all stations with the highest values apparent during September 10, 11 and 12, and the lowest value obtained on September 3. A range of approximately 400 micrograms per cubic meter of air occurred between the maximum and minimum concentrations.

Station 4 (Figure 10) had higher values than the average of all nine stations except on September 10, 11, and 12. A spread of approximately 400 micrograms per cubic meter of air was found between highest and lowest values. It is interesting to note that on September 16, an especially high concentration, 570 micrograms per cubic meter of air, was obtained at this station. This greatly exceeded the daily average of 290 micrograms per cubic meter of air at all nine stations. There is no known explanation for this high concentration.

The concentrations obtained at Station 11 (Figure 11) were frequently higher and lower but usually followed closely the general trend of the average. The concentrations at this station had a range between the high and low values of approximately 400 micrograms per cubic meter of air.

Values at Station 12 (Figure 12) had larger deviations from the average than most of the other stations. These variations were primarily lower than the average and occurred on August 13, 17, and 22, and September 3. The latter date had the minimum value for this station during the sampling period. The variation between maximum and minimum weights was more than 600 micrograms per cubic meter of air. A low of 33.1 occurred on September 3 and a high of 652.5 occurred on September 12, 1952, nine days later.

At Station 15 (Figure 13) the concentrations, in general, were higher than the average for the nine stations. This station had the highest value, 719.5 micrograms per cubic meter of air found at any of the nine stations during the sampling period. The spread between

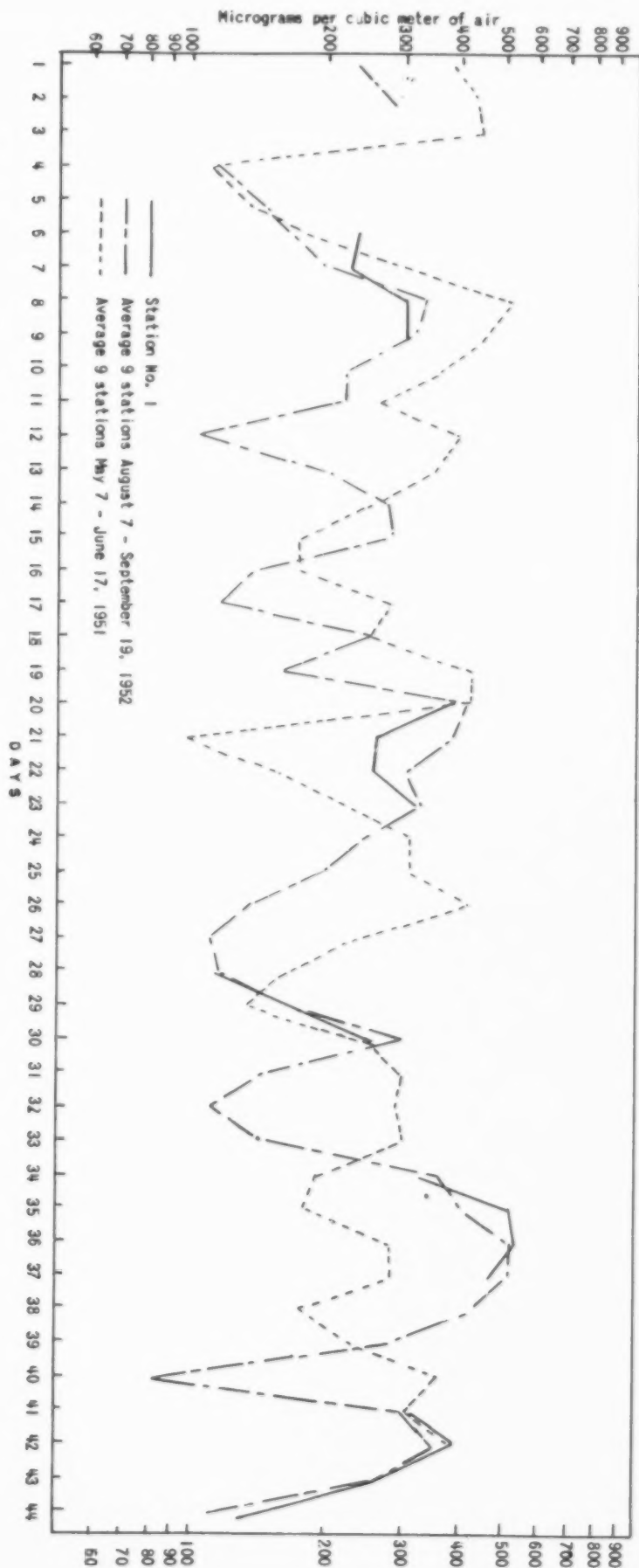


Figure 9. STATION NO. 1 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

Figure 10. STATION NO. 4 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

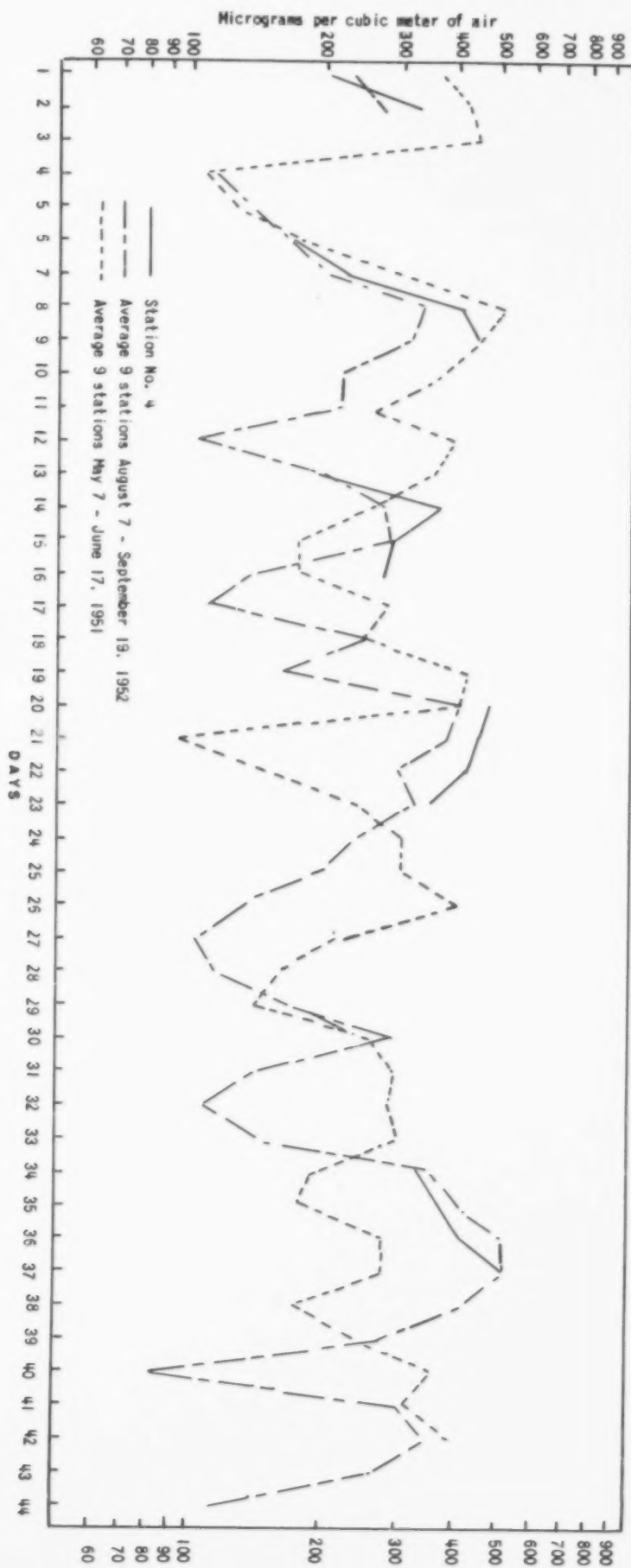


Figure 11. STATION NO. 11 - Weights (in microgram per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

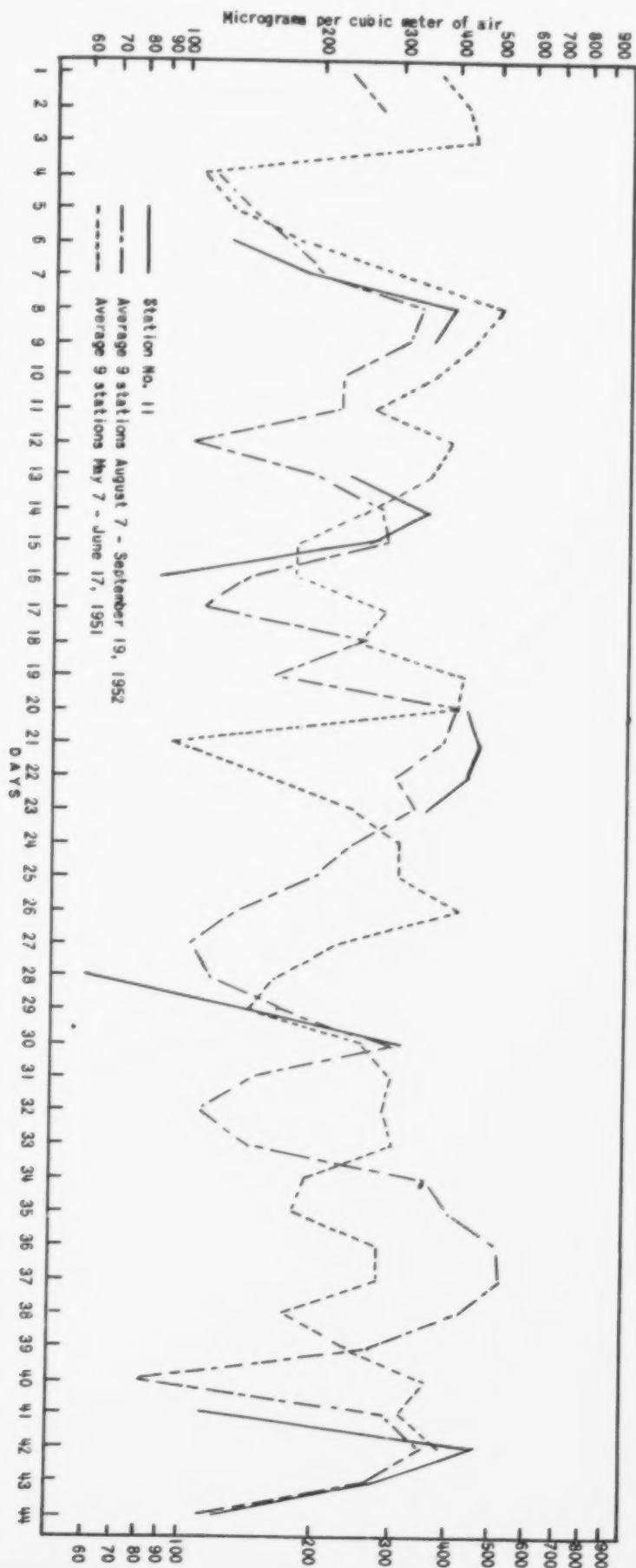
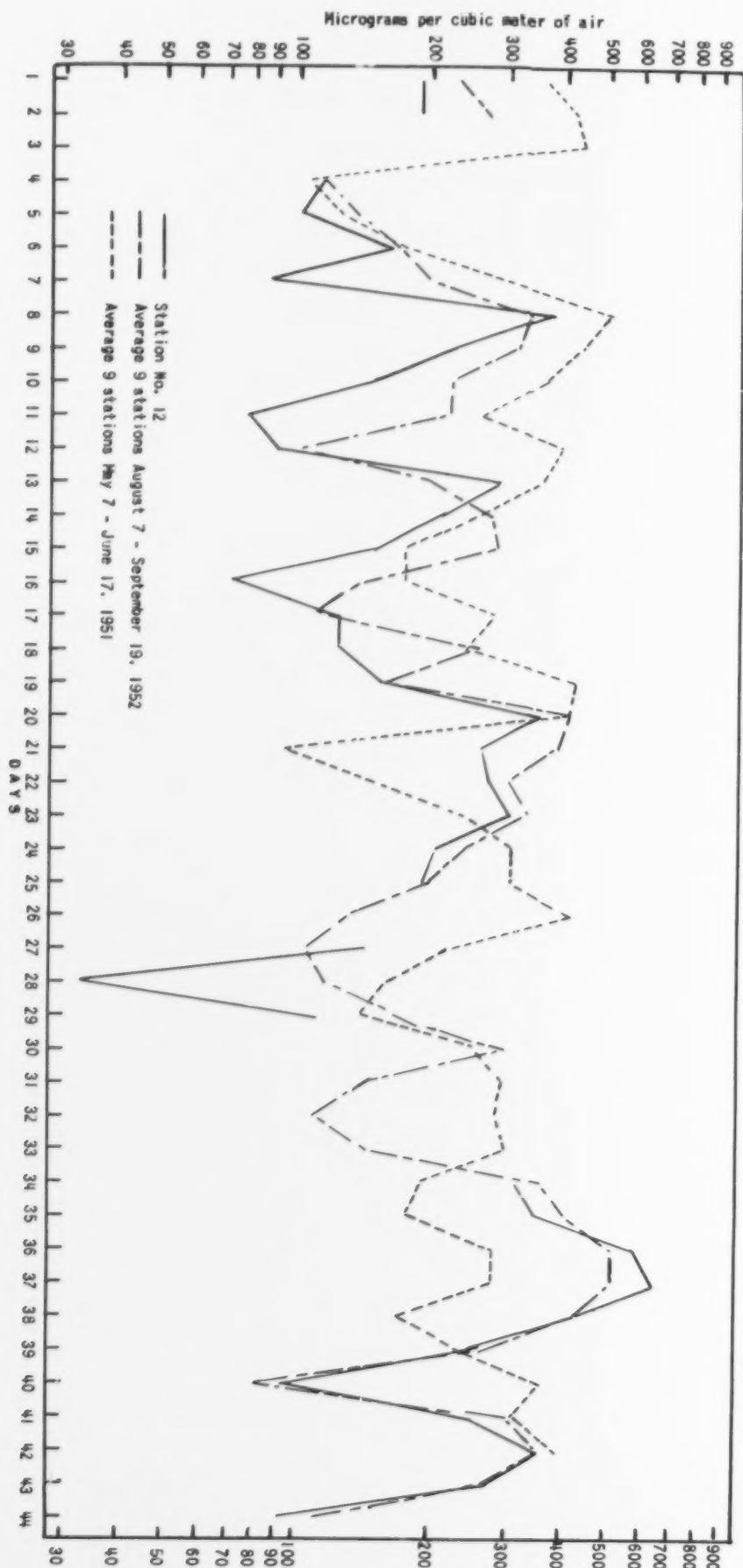


Figure 12. STATION NO. 12 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951



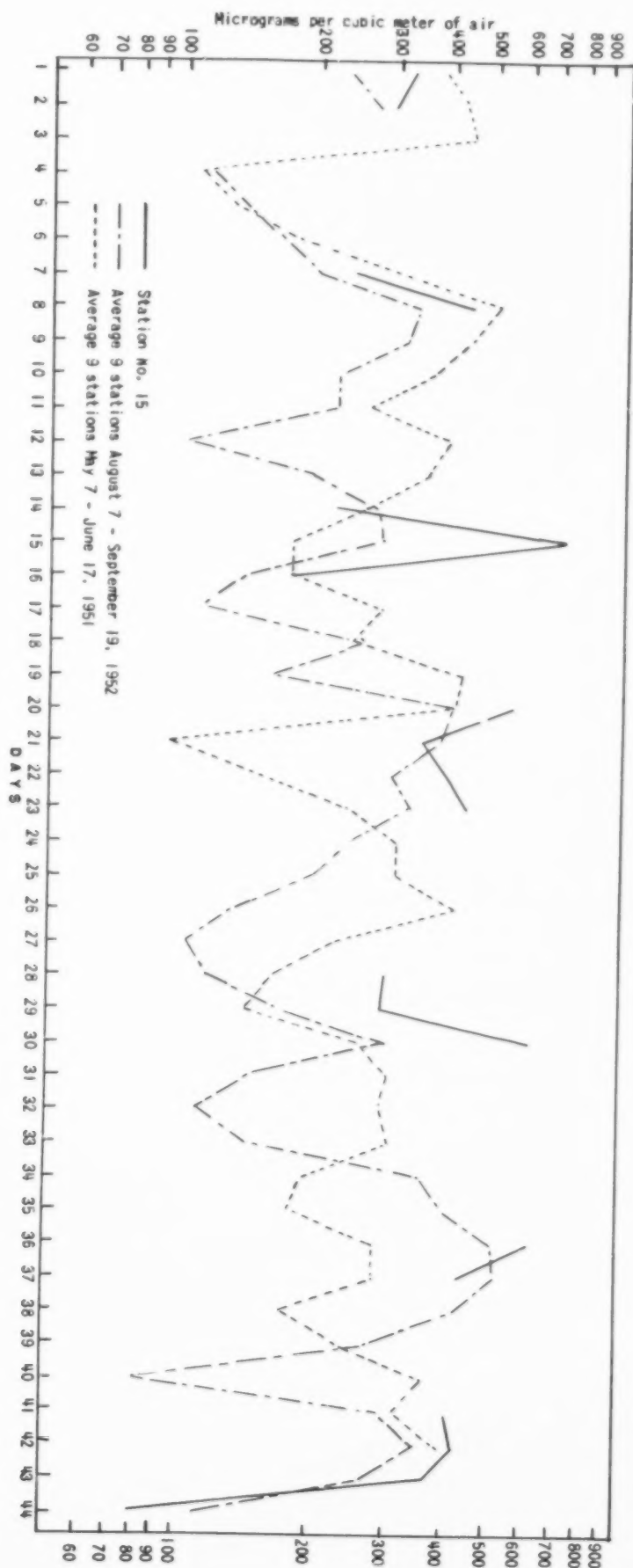


Figure 13. STATION NO. 15 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

minimum and maximum was more than 600 micrograms per cubic meter of air. The values obtained at this station were frequently above the 1951 average.

The results procured at Station 19 (Figure 14) closely followed the trend of the average. The maximum total variation between high and low values for the period was approximately 500 micrograms per cubic meter of air.

The concentrations at Station 24 (Figure 15) were primarily lower than the average, although they closely followed the general trend. There were major low values on August 12, 22, and September 19. The large number of samples, thirty-nine, collected at this station, offers a more complete comparison than some of the other stations.

Data for Station 25 (Figure 16) were meager when presented diagrammatically, as only in three instances were there data for three or more consecutive days. The data obtained, however, appear to follow the general trend of the average.

At Station 28 (Figure 17) thirty-six samples were collected. In general, the concentrations obtained at this station fluctuated similarly to the average of all stations, although in most instances the values at this station were lower than the average. It is interesting to observe that on September 3, 7, 15, and 19, extremely low concentrations were found. The total variation between high and low values for the entire sampling period was approximately 500 micrograms per cubic meter of air.

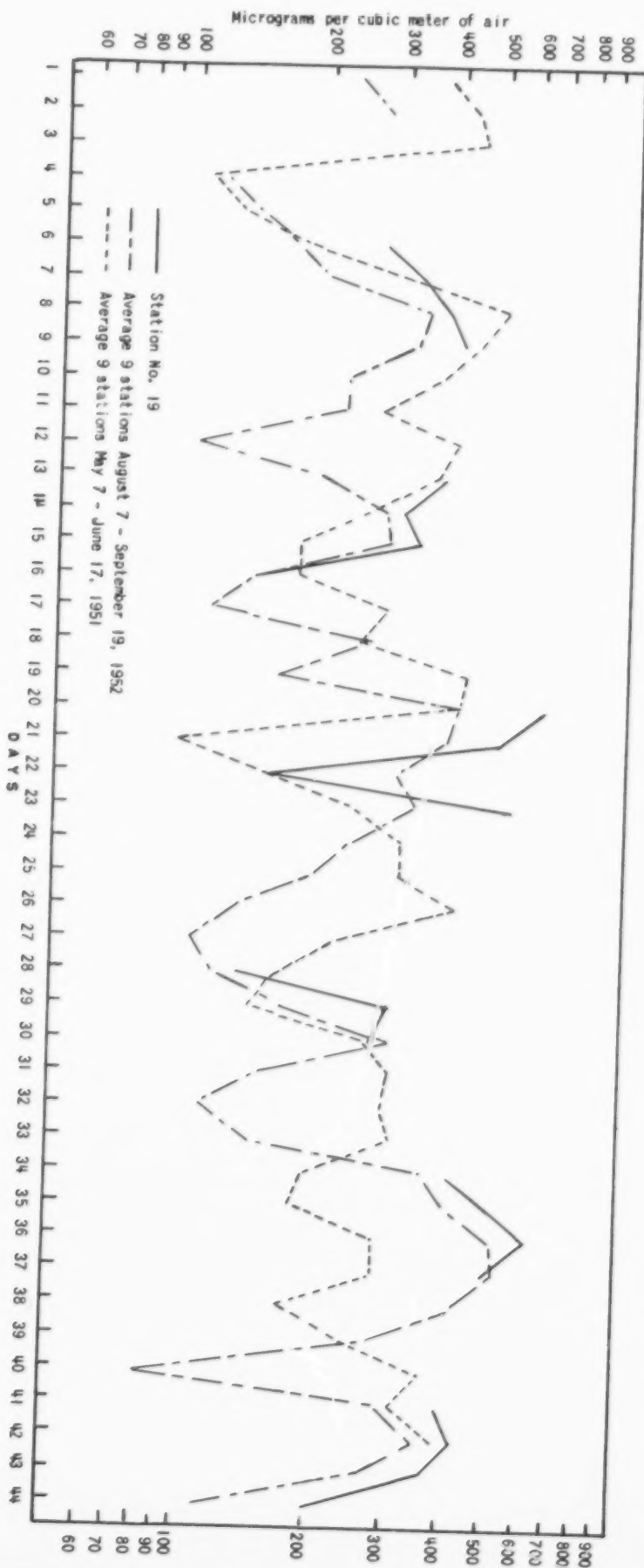
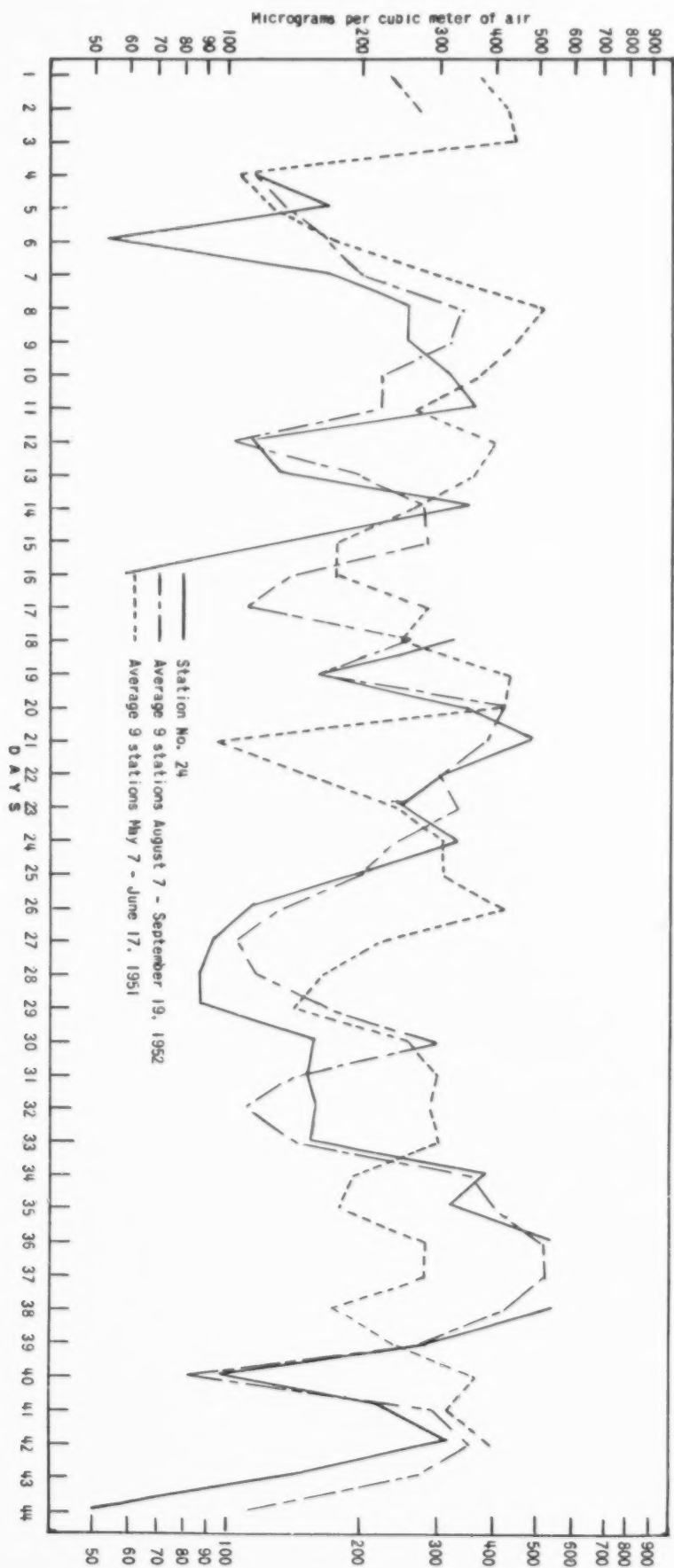


Figure 14. STATION NO. 19 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

Figure 15. STATION NO. 24 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951



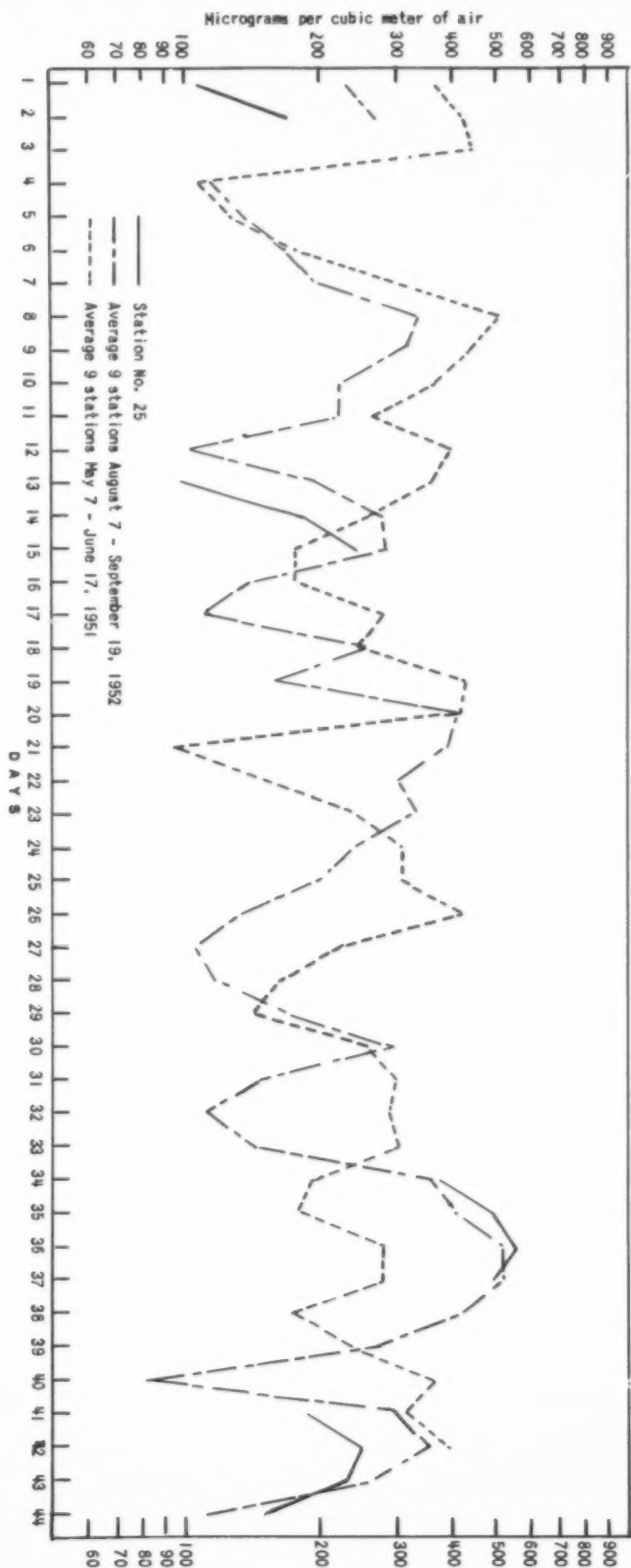
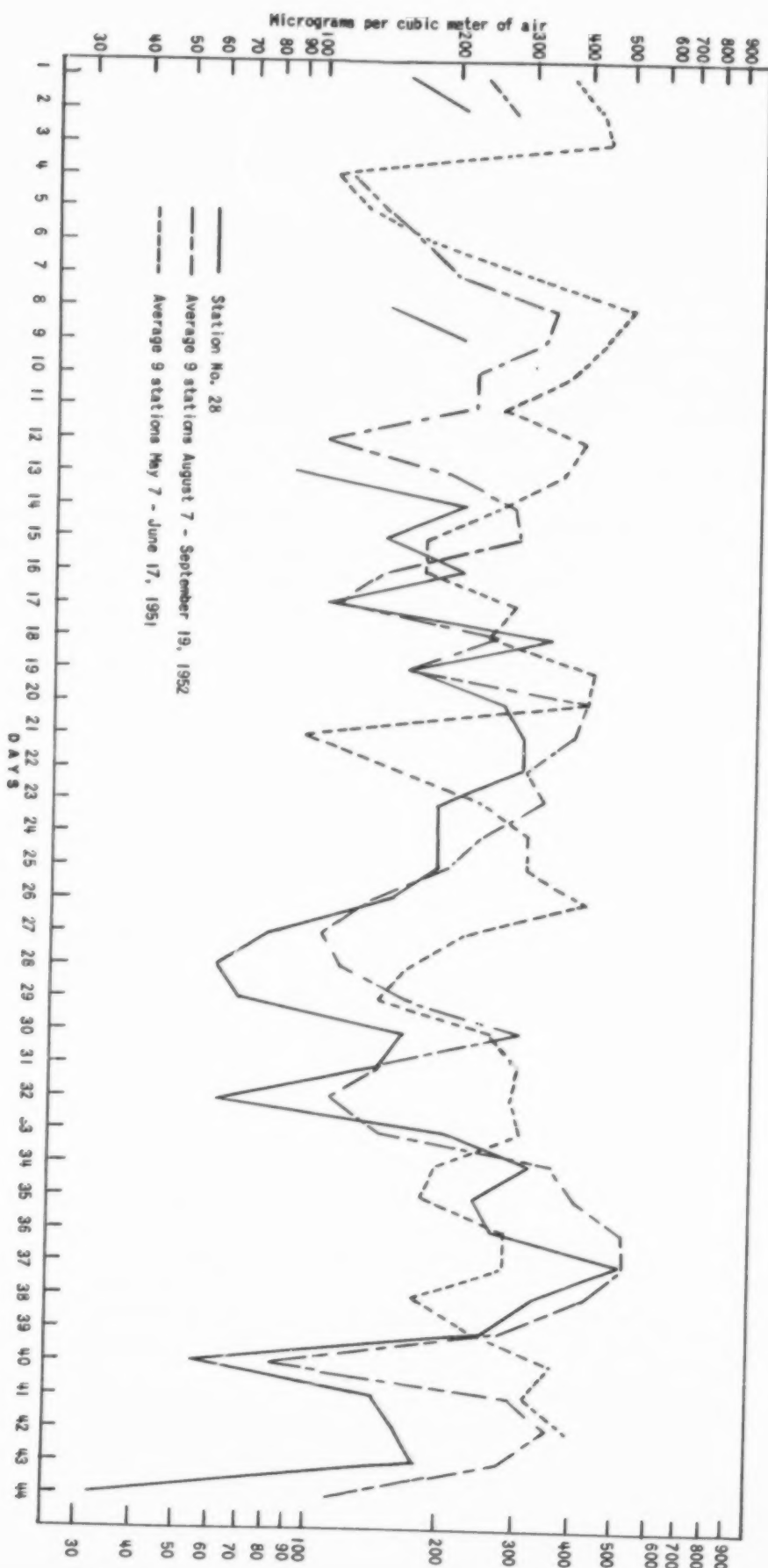


Figure 16. STATION NO. 25 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951

Figure 17. STATION NO. 28 - Weights (in micrograms per cubic meter of air) of total particulate matter for daily air samples compared with corresponding averages of all nine stations in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951



ELEMENTS

The total particulates of the high volume air samples, after being weighed, were analyzed spectrographically to identify twenty-one inorganic elements qualitatively and semiquantitatively.

Median Values

Table 5 presents the minimum, maximum and median values of the elements analyzed. Aluminum, iron and silicon were the most predominant; each had a median value of more than 1.0 microgram per cubic meter of air. Of special interest is the wide range between the minimum and maximum values for aluminum, iron, silicon and magnesium. These variations were due to the combination of pollution sources and meteorological conditions. The twenty-one elements in Table 5 are listed according to decreasing order based on 1952 median values. Also are listed the median, maximum and minimum values found in the 1951 survey for nineteen of these elements. A study of this table reveals that the greatest disconformity in median values was for silicon which had a median value of 3.3 micrograms per cubic meter of air in 1951, as compared to 1.7 in 1952. It is interesting to observe, as stated previously, that the median total weight values obtained at each station remained surprisingly constant and as seen in Table 5, the median values for the elements also remained remarkably uniform during these periods.

Comparison of Elements by Station

Figure 18 graphically presents a comparison of the average contribution (in percent) of five elements and "all others" to the total weight of the twenty-one elements as determined spectrographically by station for the periods 1951 and 1952. A study of this figure reveals that there was little change in magnesium concentrations at any of the nine stations during the years 1951 and 1952.

Aluminum, however, showed an increase at all stations in 1952, with the exception of Station 25 where the concentration remained approximately the same.

Iron showed a decrease at Stations 1, 11, 15, 19, 24, 25 and 28 in 1952, with only a minor increase at Station 4 and 12.

TABLE 5. Median, minimum and maximum figures for 21 elements determined spectrographically from samples collected at 9 stations August 7 through September 19, 1952 and for 19 elements from samples collected at the same stations May 7 through June 17, 1951

Elements	Value in micrograms per cubic meter of air					
	Aug 7 - Sept 19, 1952			May 7 - June 17, 1951		
	Med.	Min.	Max.	Med.	Min.	Max.
Aluminum	3.6	0.4	29.8	2.9	tr	17.4
Iron	2.4	tr	15.6	3.1	abs	20.7
Silicon	1.7	0.3	10.6	3.3	0.4	12.2
Magnesium	0.9	0.3	4.5	0.9	0.02	5.2
Lead	0.4	0.01	1.6	0.7	abs	3.9
Zinc	0.2	abs	1.5	0.3	abs	3.9
Manganese	0.2	0.03	0.5	0.2	0.01	0.6
Copper	0.08	abs	1.2	0.09	0.008	2.6
Titanium	0.06	abs	1.5	0.05	abs	0.4
Tin	0.04	tr	0.08	0.04	abs	0.2
Molybdenum	0.04	tr	0.09	0.04	tr	0.5
Barium	0.02	tr	0.04	0.02	abs	0.2
Chromium	0.02	tr	0.3	0.01	abs	0.2
Bismuth	0.02	abs	0.04	--	--	--
Nickel	0.009	abs	0.03	0.01	abs	0.3
Tungsten	0.009	abs	0.3	--	--	--
Vanadium	0.008	abs	0.02	0.003	abs	0.04
Antimony	tr	abs	0.03	abs	abs	0.06
Cadmium	tr	abs	0.04	0.003	abs	0.07
Cobalt	abs	abs	0.004	abs	abs	0.02
Beryllium	abs	abs	0.01	tr	abs	0.01

Note: abs - absent; tr - trace

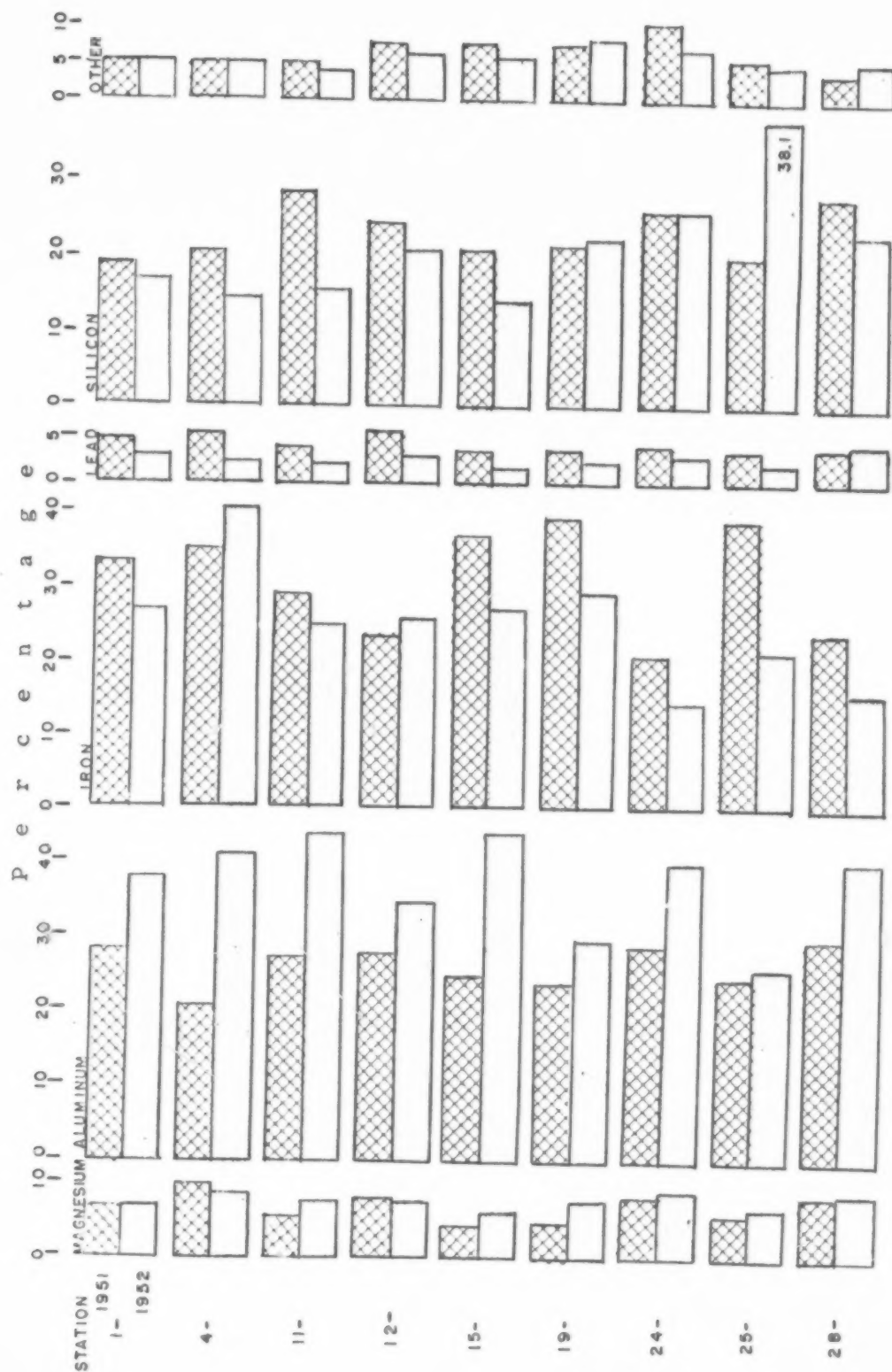


Figure 18. Average contribution (in percent) of 5 elements and "all others" to the total weight of 21 elements determined spectrographically, by station, based on daily air samples collected in the Detroit area, August 7 through September 19, 1952 and May 7 through June 17, 1951.

At all stations, except Station 28, lead showed an approximate increase of 2 percent in 1952 over 1951.

Silicon remained relatively unchanged except at Stations 11 and 25. At Station 11 there was a decrease in 1952 and at Station 25 the average was nearly double the percentage for that of 1951.

No notable variations in the percentage of "all other" elements occurred, except for a small decrease in 1952 at Station 24.

In general, the relationship between the 1951 and 1952 element data was in congruity.

A Comparison of Selected Elements by Station

Tables 6 through 9 present median, maximum and minimum values of the most predominant elements, by station, for the sampling periods August 7 through September 19, 1952 and May 7 through June 17, 1951. The stations are arranged in order of decreasing 1952 median values.

Table 6 presents the silicon values by station. In comparing 1952 results with those of 1951, it was noted that silicon median and maximum values were lower at eight of the nine stations in 1952 and minimum values were, in general, quite similar. Position relationship, based on median values, was similar for many of the stations in 1951 and 1952, with Stations 11, 12, and 19 being notable exceptions.

Table 7 shows that median values for lead in 1952 were very similar to those obtained in 1951. The relative position of each station based on median values, for lead, when compared to the relative position of the total weight, showed a close relationship for seven of the nine stations in 1952. When comparing positions of each station, good uniformity existed between 1952 and 1951 with the exception of Stations 1 and 19.

It is noted that maximum values for lead were less at all stations in 1952 than in 1951, while minimum values were quite similar.

As shown in Table 8, median values for iron were generally higher than for lead and silicon. It may be noted from this table that in 1952, relative standing based on median values for iron and total weight, were similar at each station except at Station 25. In general, the median and maximum values in 1952 were less than those in 1951.

TABLE 6. Comparison of median, maximum and minimum values for Silicon (in micrograms per cubic meter of air) for the periods August 7 through September 19, 1952 and May 7 through June 17, 1951. Stations are arranged in order of decreasing median silicon values. Also shown are positions of stations based on the median total weight value.

Position No.	Aug 7 - Sept 19, 1952					May 7 - June 17, 1951				
	Station T.W ¹ /Si ² /		Med.	Max.	Min.	Station T.W ¹ /Si ² /		Med.	Max.	Min.
1	15	25	10.3	10.7	1.0	15	11	4.0	12.2	0.7
2	19	15	2.4	8.4	0.9	4	4	3.8	11.4	0.4
3	4	4	2.0	6.5	1.1	19	25	3.7	7.2	0.9
4	11	12	1.9	8.6	0.7	11	15	3.6	10.6	1.1
5	1	1	1.7	9.0	1.3	25	19	3.3	10.2	0.9
6	12	28	1.5	6.3	0.6	1	1	2.5	10.0	1.2
7	25	11	1.4	4.3	0.6	24	28	2.5	10.8	0.5
8	28	24	1.4	9.4	0.3	12	12	2.2	4.9	0.7
9	24	19	1.2	5.2	0.7	28	24	1.9	7.4	0.8

1/ Total weight. - Relative standing of station in terms of median value of total weight of particulate matter.

2/ Silicon. - Relative standing of station in terms of median value of total weight of silicon.

TABLE 7. Comparison of median, maximum and minimum values for Lead (in micrograms per cubic meter of air) for the periods August 7 through September 19, 1952 and May 7 through June 17, 1951. Stations are arranged in order of decreasing median lead values. Also shown are positions of stations based on the median total weight value.

Position No.	Aug 7 - Sept 19, 1952					May 7 - June 17, 1951				
	Station T.W ^{1/} /Pb ^{2/}		Med.	Max.	Min.	Station T.W ^{1/} /Pb ^{2/}		Med.	Max.	Min.
1	15	4	0.7	1.0	0.2	15	4	0.8	3.9	0.3
2	19	1	0.6	1.5	0.08	4	15	0.8	2.9	0.2
3	4	15	0.6	1.5	0.1	19	1	0.7	3.5	0.3
4	11	25	0.4	0.9	0.3	11	19	0.7	3.4	0.04
5	1	11	0.4	0.6	0.1	25	25	0.7	2.6	0.1
6	12	12	0.4	1.6	0.09	1	12	0.6	2.9	abs
7	25	19	0.3	0.7	0.01	24	11	0.5	2.7	0.02
8	28	24	0.3	1.3	0.02	12	28	0.4	2.5	abs
9	24	28	0.2	1.6	0.02	28	24	0.2	2.3	abs

1/ Total weight. - Relative standing of station in terms of median value of total weight of particulate matter.

2/ Lead. - Relative standing of station in terms of median value of total weight of lead.

Note: abs - absent.

TABLE 8. Comparison of median, maximum and minimum values for Iron (in micrograms per cubic meter of air) for the periods August 7 through September 19, 1952 and May 7 through June 17, 1951. Stations are arranged in order of decreasing median iron values. Also shown are positions of stations based on the median total weight value.

Position No.	Aug 7 - Sept 19, 1952					May 7 - June 17, 1951				
	Station T.W ¹ / ₁ /Fe ² / ₂		Med.	Max.	Min.	Station T.W ¹ / ₁ /Fe ² / ₂		Med.	Max.	Min.
1	15	15	3.4	14.9	2.9	15	4	6.9	15.5	0.5
2	19	25	3.3	6.5	1.4	4	15	6.1	19.4	0.8
3	4	1	2.8	12.5	0.5	19	19	5.8	18.3	0.8
4	11	4	2.7	15.6	0.7	11	25	4.7	20.7	0.2
5	1	19	2.4	6.8	0.7	25	11	3.1	13.3	0.4
6	11	11	2.4	6.2	1.5	1	1	2.6	17.4	1.0
7	25	12	1.8	15.2	0.5	24	12	2.3	8.8	abs
8	28	24	1.4	3.2	0.4	12	28	1.7	16.3	abs
9	24	28	0.8	7.2	tr	28	24	1.3	7.4	abs

1/ Total weight. - Relative standing of station in terms of median value of total weight of particulate matter.

2/ Iron. - Relative standing of station in terms of median value of total weight of iron.

Note: abs - absent; tr - trace

TABLE 9. Comparison of median, maximum and minimum values for Aluminum (in micrograms per cubic meter of air) for the periods August 7 through September 19, 1952 and May 7 through June 17, 1951. Stations are arranged in order of decreasing median aluminum values. Also shown are positions of stations based on the median total weight value.

Position No.	Aug 7 - Sept 19, 1952					May 7 - June 17, 1951				
	Station T.W. ¹ /Al ² /		Med.	Max.	Min.	Station T.W. ¹ /Al ² /		Med.	Max.	Min.
1	15	1	6.0	12.5	1.9	15	15	3.6	16.7	1.1
2	19	15	5.2	29.8	3.1	4	25	3.4	14.2	0.6
3	4	25	4.4	8.8	1.4	19	4	3.4	11.4	0.5
4	11	11	3.9	12.3	1.5	11	19	3.2	14.6	0.9
5	1	4	3.6	23.4	0.7	25	1	2.9	17.4	1.0
6	12	19	3.0	7.8	2.3	1	11	2.9	13.3	0.8
7	25	12	2.9	15.2	0.9	24	12	2.4	8.8	0.1
8	28	24	2.8	12.8	0.6	12	28	1.7	16.3	tr
9	24	28	2.1	10.8	0.4	28	24	1.5	11.1	0.2

¹/ Total weight. - Relative standing of station in terms of median value of total weight of particulate matter.

²/ Aluminum. - Relative standing of station in terms of median value of total weight of aluminum.

Note: tr - trace

TABLE 10. Relative standing of each station by total weight, 10 elements and a weighted summation of the 10 elements based on median values of samples collected August 7 - September 19, 1952

Sta.	T.W. ^{1/}	Si.	Fe.	Ca.	Al.	Pb.	Mo.	Mg.	Mn.	Zn.	Cu.	Sum. ^{2/}
15	1	2	1	4	2	3	2	9	2	5	5	2
19	2	9	5	8	6	7	4	6	7	3	4	8
4	3	3	4	3	5	1	5	1	6	1	2	4
11	4	7	6	9	4	5	6	8	8	8	7	9
1	5	5	3	5	1	2	3	3	5	4	1	3
12	6	4	7	2	7	6	7	4	4	6	8	5
25	7	1	2	1	3	4	1	2	1	2	6	1
28	8	6	9	6	9	9	9	5	9	9	9	7
24	9	8	8	7	8	8	8	7	3	7	3	6

^{1/} Total weight of particulate matter (in relative standing).

^{2/} Summation of median values of 10 elements.

Table 9 presents median, maximum and minimum aluminum values for the sampling periods in 1951 and 1952. The stations are arranged in decreasing aluminum median values. A study of the relative position of each station, based on median aluminum values and median total weight values for 1952, showed that six of the nine stations were similar. The exceptions were Stations 1, 19, and 25. Median values for aluminum were greater in 1952 than in 1951 except for Station 1. The position for each station, based on aluminum median values, remained relatively the same during the sampling periods of 1951 and 1952.

Relative Position of Stations

Table 10 presents the relative standing of each station by median values of total weight, ten elements and the summation of the ten elements. The station with the highest total weight median value was given a rating of one, the second highest median value was given a rating of two, etc. The same procedure was used in rating each of the ten elements. The ratings given to each station, based on the summary of the ten elements, thus the station with the highest total element median value was given a rating of one and the station with the second highest median value was given a rating of two, etc. Except for Stations 11, 19, and 25, the comparison of the relative standing of stations in terms of total particulate matter to the summation of the ten elements showed relatively good agreement.

Station 11 was rated fourth in total weight but was ninth position in the summation of the ten elements. This difference between the total weight and the elements may have been due to organic compounds, as a large number of coal consuming industries were located in the vicinity of the sampling station.

Station 19 was rated second in total weight and eighth in summation of the selected elements. The difference in rating between the total weight and summation of the elements at this station was also probably due to the organic compounds in the atmosphere.

Station 25 was rated seventh in total weight and first in the summation of the ten elements. It was first in silicon, calcium, molybdenum, magnesium, second in iron, manganese and zinc and third and fourth in aluminum and lead. In 1951 the relative standing of total weight and of all the elements was also high at this station. The higher total weight rating in 1951 was probably due to a great extent to the road construction

TABLE 11

Percentage frequency distributions, medians, minimum and maximum figures for 22 elements determined spectrographically (in micrograms per cubic meter of air) for air samples collected daily at 9 sampling stations in the Detroit area August 7 through September 19, 1952.

Weight (Micrograms per cubic meter of air)	AIR SAMPLING STATION									
	1	4	11	12	15	19	24	25	28	
CALCIUM										
0.0 - 5.0	14.3	0.0	75.0	7.2	20.0	28.6	7.7	0.0	6.7	
5.0 - 10.0	14.3	28.6	25.0	21.4	20.0	42.8	53.8	40.0	40.0	
>10.0	71.4	71.4	0.0	71.4	60.0	28.6	38.5	60.0	53.3	
Median	11.111	11.696	4.232	11.825	11.625	6.508	9.135	13.146	10.537	
Minimum	2.007	6.718	1.310	2.811	1.987	0.973	1.683	5.514	3.195	
Maximum	15.021	15.192	9.222	16.273	14.903	17.271	15.595	17.746	21.053	
MAGNESIUM										
0.0 - 0.75	28.6	0.0	50.0	35.7	40.0	28.6	38.5	0.0	40.0	
0.75 - 1.5	42.8	28.6	25.0	57.1	40.0	71.4	43.1	80.0	40.0	
>1.5	28.6	71.4	25.0	7.2	20.0	0.0	15.4	20.0	20.0	
Median	1.084	2.154	0.828	0.933	0.561	0.867	0.832	1.320	0.875	
Minimum	0.407	0.800	0.327	0.295	0.596	0.740	0.252	0.898	0.259	
Maximum	3.289	3.509	1.844	2.286	4.471	1.295	1.926	1.937	2.153	
NICKEL										
0.001 - 0.010	80.0	33.3	75.0	33.3	40.0	40.0	75.0	0.0	50.0	
>0.011	20.0	66.7	25.0	66.7	60.0	60.0	25.0	100.0	50.0	
Median	0.005	0.011	0.009	0.010	0.011	0.016	0.004	0.011	tr	
Minimum	abs	tr	0.003	abs	0.002	tr	tr	abs	abs	
Maximum	0.020	0.017	0.014	0.026	0.012	0.019	0.024	0.013	0.029	
COPPER										
0.001 - 0.099	42.9	16.7	100.0	28.6	60.0	33.3	46.2	66.7	50.0	
>0.10	57.1	83.3	0.0	71.4	40.0	66.7	53.8	33.3	50.0	
Median	0.233	0.136	0.031	0.070	0.081	0.086	0.109	0.037	0.059	
Minimum	0.055	tr	abs	abs	0.035	tr	0.015	abs	abs	
Maximum	0.311	0.342	0.071	0.288	0.149	1.168	0.183	0.129	0.323	
ALUMINUM										
0.0 - 2.5	14.3	28.6	50.0	35.7	0.0	14.3	30.8	20.0	53.3	
2.5 - 5.0	14.3	28.6	0.0	42.9	40.0	71.4	46.1	60.0	20.0	
>5.0	71.4	42.8	50.0	21.4	60.0	14.3	23.1	20.0	26.7	
Median	6.022	3.589	3.902	2.933	5.216	2.988	2.815	4.401	2.100	
Minimum	1.852	0.718	1.489	0.878	3.049	2.268	0.631	1.402	0.420	
Maximum	12.512	23.392	12.296	15.238	29.806	7.785	12.837	8.764	10.764	

TABLE 11. Continued

	1	4	11	12	15	19	24	25	28
ZINC									
0.0 - 2.5	42.8	14.3	0.0	64.3	60.0	42.8	76.9	100.0	86.6
2.5 - 5.0	42.8	57.1	25.0	21.4	20.0	57.2	23.1	0.0	6.7
>5.0	14.4	28.6	0.0	14.3	20.0	0.0	0.0	0.0	6.7
Median	0.283	0.449	0.138	0.203	0.186	0.284	0.145	0.323	0.059
Minimum	tr	0.182	tr	abs	0.145	0.130	abs	tr	abs
Maximum	0.803	1.519	0.268	0.762	0.795	0.324	0.321	0.438	0.585
MOLYBDENUM									
0.001 - 0.020	14.3	16.7	50.0	53.8	0.0	16.7	92.3	20.0	39.2
>0.020	85.7	83.3	50.0	46.2	100.0	83.3	7.7	80.0	30.8
Median	0.038	0.036	0.025	0.018	0.041	0.038	0.016	0.044	0.013
Minimum	0.019	0.017	0.015	tr	0.035	tr	0.005	0.011	tr
Maximum	0.047	0.057	0.062	0.076	0.093	0.076	0.048	0.044	0.059
MANGANESE									
0.001 - 0.200	57.1	57.1	75.0	57.1	40.0	57.1	69.2	40.0	43.3
>0.200	42.9	42.9	25.0	42.9	60.0	42.9	30.8	60.0	26.7
Median	0.175	0.156	0.141	0.177	0.224	0.148	0.183	0.323	0.133
Minimum	0.113	0.139	0.060	0.070	0.116	0.065	0.034	0.142	0.053
Maximum	0.302	0.269	0.268	0.495	0.278	0.250	0.312	0.396	0.421
CHROMIUM									
0.001 - 0.014	42.9	42.9	50.0	53.6	40.0	16.7	100.0	25.0	75.0
>0.014	57.1	57.1	50.0	36.4	60.0	83.3	0.0	75.0	25.0
Median	0.018	0.015	0.015	0.011	0.020	0.017	0.003	0.017	0.002
Minimum	0.004	0.003	0.010	tr	0.010	tr	tr	tr	tr
Maximum	0.025	0.020	0.015	0.281	0.067	0.151	0.013	0.263	0.234
IRON									
0.0 - 2.5	42.8	14.3	50.0	64.3	0.0	57.1	84.6	20.0	80.0
2.5 - 5.0	14.4	42.8	25.0	21.4	40.0	14.3	15.4	60.0	13.3
>5.0	42.8	42.8	25.0	14.3	60.0	28.6	0.0	20.0	6.7
Median	2.827	2.724	2.367	1.772	3.374	2.441	1.447	3.301	0.841
Minimum	0.481	0.661	1.489	0.454	2.906	0.740	0.367	1.422	tr
Maximum	12.512	15.595	6.148	15.238	14.903	6.791	3.209	6.457	7.176
ANTIMONY									
0.001 - 0.015	75.0	30.0	100.0	80.0	100.0	33.3	0.0	50.0	100.0
>0.015	25.0	50.0	0.0	20.0	0.0	66.7	100.0	50.0	0.0
Median	0.008	tr	tr	0.010	0.011	0.017	tr	abs	0.006
Minimum	abs	abs	abs	abs	abs	abs	abs	abs	abs
Maximum	0.032	0.017	0.011	0.018	0.012	0.030	0.018	0.022	0.015

TABLE 11. Continued

	1	4	11	12	15	19	24	25	28
BARIUM									
0.001 - 0.015	57.1	33.3	33.3	53.8	40.0	42.9	33.3	100.0	85.7
>0.015	42.9	66.7	66.7	46.2	60.0	57.1	66.7	0.0	14.3
Median	0.014	0.027	0.017	0.012	0.016	0.016	0.008	0.013	0.006
Minimum	0.011	tr	tr	tr	0.004	0.011	0.002	0.004	0.002
Maximum	0.031	0.031	0.030	0.036	0.030	0.035	0.026	0.013	0.029
COBALT									
Present	14.3	57.1	0.0	21.4	60.0	0.0	7.7	20.0	13.3
LEAD									
0.0 - 0.5	28.6	14.3	75.0	57.1	40.0	71.4	76.9	60.0	73.3
0.5 - 1.0	57.1	57.1	25.0	28.6	40.0	28.6	15.4	40.0	6.7
>1.0	14.3	28.6	0.0	14.3	20.0	0.0	7.7	0.0	20.0
Median	0.626	0.718	0.427	0.390	0.610	0.340	0.316	0.431	0.240
Minimum	0.082	0.182	0.149	0.088	0.145	0.010	0.018	0.351	0.016
Maximum	1.502	1.043	0.615	1.627	1.490	0.754	1.284	0.877	1.620
SILICON									
0.0 - 2.5	71.4	71.4	75.0	71.4	80.0	57.1	61.5	40.0	73.3
2.5 - 5.0	14.3	0.0	25.0	21.4	0.0	28.6	30.8	0.0	20.0
>5.0	14.3	28.6	0.0	7.2	20.0	14.3	7.7	60.0	6.7
Median	1.667	2.015	1.411	1.883	2.385	1.168	1.370	10.331	1.514
Minimum	1.272	1.090	0.566	0.703	0.872	0.684	0.295	1.010	0.614
Maximum	9.012	6.461	4.287	8.621	8.345	5.181	9.357	10.648	6.316
TIN									
0.001 - 0.030	14.3	14.3	50.0	57.1	20.0	28.6	76.9	20.0	85.7
>0.030	85.7	85.7	50.0	42.9	80.0	71.4	23.1	80.0	14.3
Median	0.051	0.049	0.031	0.029	0.041	0.043	0.025	0.043	0.017
Minimum	0.022	0.029	0.015	0.004	0.029	0.026	0.005	0.030	tr
Maximum	0.068	0.054	0.046	0.061	0.056	0.068	0.035	0.057	0.079
TITANIUM									
0.001 - 0.050	28.6	28.6	25.0	64.3	20.0	42.9	83.3	40.0	71.4
>0.050	71.4	71.4	75.0	35.7	80.0	57.1	16.7	60.0	28.6
Median	0.055	0.058	0.064	0.045	0.101	0.056	0.040	0.057	0.029
Minimum	0.022	0.020	0.242	0.011	0.045	0.023	tr	0.034	abs
Maximum	0.097	0.252	0.153	0.381	1.490	0.098	0.080	0.108	0.079

TABLE 11. Continued

	1	4	11	12	15	19	24	25	28
CADMIUM									
0.001 - 0.005	80.0	63.7	100.0	85.7	25.0	66.7	83.3	100.0	75.0
>0.005	20.0	33.3	0.0	14.3	75.0	33.3	16.7	0.0	25.0
Median	0.003	tr	0.001	0.001	0.012	tr	0.002	tr	tr
Minimum	tr	tr	tr	abs	tr	abs	abs	tr	abs
Maximum	0.014	0.011	0.003	0.020	0.017	0.038	0.009	0.004	0.009
BERYLLIUM									
Present	0.0	42.8	0.0	35.7	40.0	28.6	30.8	20.0	20.0
Median	0.0	abs	abs	abs	abs	abs	tr	abs	0.002
Minimum	0.0	abs	abs	abs	abs	abs	abs	abs	abs
Maximum	0.0	0.002	abs	0.004	0.010	tr	tr	tr	0.002
VANADIUM									
0.001 - 0.010	60.0	13.7	50.0	33.3	100.0	40.0	75.0	50.0	75.0
>0.010	40.0	83.3	50.0	66.7	0.0	60.0	25.0	50.0	25.0
Median	0.008	0.011	0.010	0.010	0.012	0.010	0.003	abs	0.006
Minimum	abs	abs	0.003	abs	abs	abs	abs	abs	abs
Maximum	0.016	0.015	0.014	0.015	0.022	0.015	0.011	0.022	0.012
BISMUTH									
0.001 - 0.015	28.6	16.7	75.0	58.3	20.0	57.1	45.5	60.0	91.6
>0.015	71.4	83.3	25.0	41.7	80.0	42.9	54.5	40.0	8.4
Median	0.019	0.017	0.012	0.011	0.019	0.011	0.015	0.013	0.010
Minimum	0.004	tr	0.009	abs	0.009	0.010	tr	0.011	tr
Maximum	0.024	0.036	0.029	0.030	0.033	0.035	0.029	0.022	0.023
TUNGSTEN									
0.001 - 0.020	60.0	50.0	57.1	50.0	25.0	50.0	87.5	0.0	60.0
>0.020	40.0	50.0	42.9	50.0	75.0	50.0	12.5	100.0	40.0
Median	0.020	0.018	0.009	0.015	0.020	0.020	0.009	0.011	0.014
Minimum	abs	abs	tr	abs	abs	abs	abs	abs	abs
Maximum	0.041	0.134	0.018	0.305	0.298	0.051	0.032	0.022	0.044

that was in progress during that sampling period. This work, however, was completed before the 1952 study.

Percentage Frequency Distribution

Table 11 shows the percentage frequency distribution and median, maximum and minimum values for twenty-two elements, determined spectrographically, at each of the nine stations.

A study of this table shows that Station 11 and 19 had lower median values for calcium, while the other seven stations had approximately similar median values.

Station 4 showed the highest median value for magnesium; approximately twice that of any other station. Although lower than Stations 1 and 25, the other stations each had similar median values.

The median and maximum values for nickel, molybdenum, manganese, chromium, antimony, barium, cobalt, tin, titanium, cadmium, beryllium, vanadium, bismuth and tungsten were low at all stations.

The median values for aluminum were lowest at Station 28 and highest at Station 1, with values of 2.100 and 6.022 micrograms per cubic meter of air, respectively. The median values for the other stations ranged from 2.815 to 5.216.

The median values for iron were rather uniform at all stations except at Station 28 which had the lowest median value of 0.841 micrograms per cubic meter of air. It may be observed in Table 11 that the maximum values for iron ranged from a low of 3.209 at Station 24 to a high of 15.595 at Station 4. The minimum values ranged from a trace at Station 28 to a high of 2.906 at Station 15.

Silicon was fairly uniform at all stations except at Station 25 which showed an exceptionally large value of 10.333 micrograms per cubic meter of air.

Relationship of Air-borne Samples to Soil Samples

A study was made to evaluate the relationship of the elements found in air-borne samples to the elements contained in the soil. This study was made to determine the relationship of those contaminants which are being initially discharged into the atmosphere by industrial and residential sources, to those being redispersed from the soil into the atmosphere as the result of wind movement.

TABLE 12. Relationship of 22 elements in air-borne samples to soil samples at three stations in Detroit

Elements	Milligrams per gram of sample					
	Station 12		Station 4		Station 24	
	Air	Soil	Air	Soil	Air	Soil
Calcium	62.73	19.77	45.23	15.98	67.54	9.97
Aluminum	23.52	9.89	40.05	14.98	29.62	7.48
Iron	16.72	0.79	25.60	12.58	10.78	6.24
Silicon	13.73	5.93	12.34	11.99	17.25	8.97
Magnesium	5.07	2.37	8.50	3.00	6.40	1.60
Lead	2.81	0.26	3.08	0.50	2.61	nd
Zinc	1.11	tr	2.29	0.26	0.90	nd
Manganese	1.11	0.59	0.81	0.40	1.11	0.30
Titanium	0.42	0.26	0.33	0.12	0.29	0.50
Copper	0.35	nd	0.63	tr	0.67	nd
Tungsten	0.20	0.10	0.15	tr	0.10	0.06
Tin	0.18	0.08	0.18	0.10	0.17	0.02
Chromium	0.16	tr	0.04	0.06	0.02	tr
Molybdenum	0.15	0.06	0.15	0.10	0.12	tr
Bismuth	0.06	tr	0.07	tr	0.01	nd
Barium	0.06	0.16	0.07	0.16	0.07	tr
Nickel	0.04	0.02	0.04	0.20	0.05	0.10
Antimony	0.01	nd	0.01	0.06	0.01	nd
Cadmium	0.01	tr	0.008	tr	nd	nd
Vanadium	0.01	nd	0.04	tr	0.07	nd
Beryllium	0.001	nd	0.001	nd	0.01	nd
Cobalt	0.001	nd	0.001	nd	nd	nd

Note: tr - trace; nd - not detected

Table 12 shows the results of this study. The data presented for air-borne samples were obtained by averaging for Station 12, 14 samples; Station 4, 6 samples and Station 24, 13 samples. These were collected during the period August 7 through September 19, 1952. The soil samples were obtained by scraping 1/2 inch of the top soil over an area of one foot square, mixing thoroughly and taking a representative sample for analysis. The soil samples were taken in the same vicinity as the air-borne samples at each station.

It may be seen from this table that with the exceptions of titanium at Station 24, barium at Stations 4 and 12, nickel at Stations 4 and 24, chromium and antimony at Station 4, the air-borne samples contained higher concentrations of the elements than did the soil samples. In the case of calcium, the air-borne samples contained three or more times that found in the soil samples. Aluminum, iron and lead were also appreciably greater in air samples than in the soil samples. Although the air contained small amounts of cadmium, vanadium, beryllium and cobalt, these elements were either not detected or only in trace amounts in the soil.

It may be concluded from these data that a considerable portion of the samples was representative of the initial pollutant discharges to the atmosphere; however, none of the elements could be used as an index to represent the amount of soil collected in the air samples.

Table 13 shows the percentage of each element to the sum of the twenty-two elements of air-borne and soil samples. In both air-borne and soil samples, calcium, aluminum, iron and silicon composed approximately 90 percent of the weight of the twenty-two elements at all three stations.

TABLE 13. Percentage of each element to the sum of 22 elements for air-borne and soil samples at three stations in Detroit

Elements	P E R C E N T A G E					
	Station 12		Station 4		Station 24	
	Air	Soil	Air	Soil	Air	Soil
Calcium	48.82	49.09	32.41	26.42	48.80	28.30
Aluminum	18.29	24.55	28.67	24.77	21.40	21.22
Iron	13.00	1.96	18.32	20.81	7.80	17.71
Silicon	10.68	14.72	8.84	19.82	12.80	25.47
Magnesium	3.96	5.89	6.08	4.95	4.60	4.53
Lead	2.18	0.64	2.21	0.82	1.90	nd
Zinc	0.86	tr	1.64	0.43	0.70	nd
Manganese	0.86	1.47	0.57	0.66	0.80	0.85
Titanium	0.33	0.64	0.24	0.20	0.20	1.41
Copper	0.27	nd	0.45	tr	0.50	nd
Tungsten	0.16	0.25	0.01	tr	0.07	0.17
Tin	0.14	0.20	0.12	0.17	0.12	0.06
Chromium	0.13	tr	0.04	0.10	0.02	tr
Molybdenum	0.12	0.15	0.11	0.17	0.09	tr
Bismuth	0.05	tr	0.05	tr	0.01	nd
Barium	0.05	0.39	0.05	0.26	0.05	tr
Nickel	0.03	0.05	0.03	0.33	0.05	0.28
Antimony	0.02	nd	0.01	0.10	0.01	nd
Vanadium	0.02	nd	0.02	tr	0.05	tr
Cadmium	0.01	tr	0.001	tr	nd	nd
Beryllium	0.001	nd	0.001	nd	0.01	nd
Cobalt	0.001	nd	0.001	nd	nd	nd

Note: tr - trace; nd - not detected

Comparison of Pollutants Collected on Sundays and Wednesdays

A study of the data was made to determine the relationship of the contaminants found in the Detroit River area on Sundays, when community activity was slight, to Wednesdays, when the community activity was presumed to be normal for the weekdays.

Table 14 presents a comparison of the total weight, six of the major elements, "all others" and the total of the elements for the average values obtained on Sundays and Wednesdays at three stations. It is interesting to observe in this table that there was a large variation in total weight of the particulates between Sundays and Wednesdays, with only a small variation in the average total weight of the twenty-two elements.

At Station 12 total particulate matter, aluminum and iron showed a large increase on Wednesdays as compared to Sundays. Conversely, calcium and silicon showed a decrease on Wednesdays, whereas magnesium, lead, and the total of all elements did not show any material change between the two days.

At Station 24 total particulates on Wednesdays averaged approximately double the Sundays weight, and there was a slight increase in all of the elements except silicon.

At Station 28 the increase in average total weight on Wednesdays was approximately 40 percent. This was appreciably less than at Stations 12 and 24.

TABLE 14. Comparison of samples collected at three stations on Sundays and Wednesdays during the period August 7 through September 19, 1952 in the Detroit area.

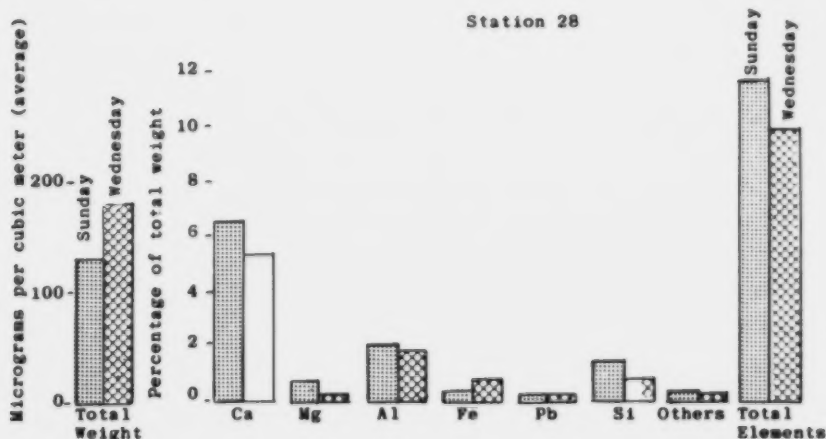
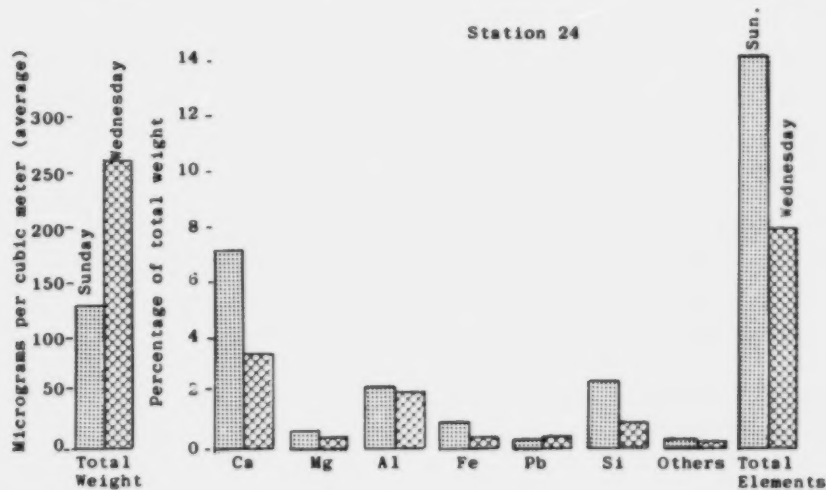
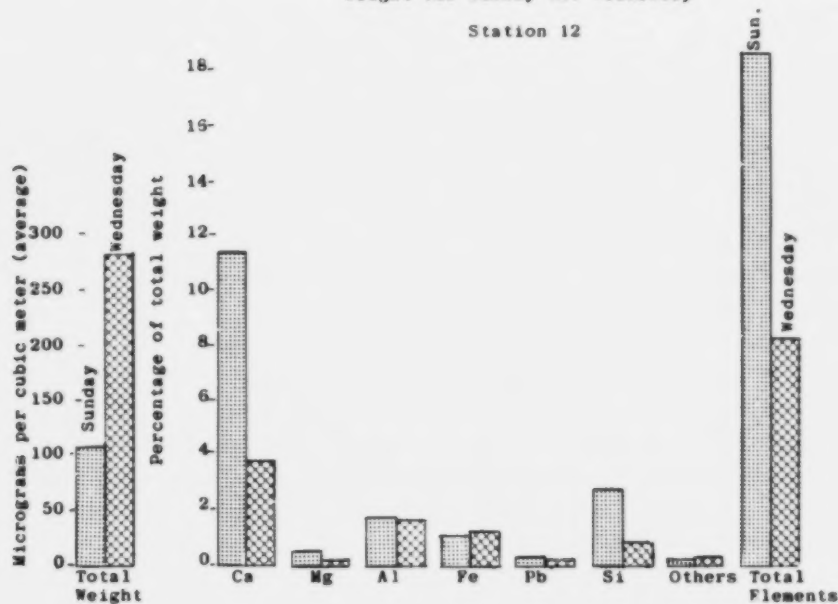
Day	Sta.	No. of Samples	Micrograms per cubic meter of air								Average Total Elements
			Average Total Weight	Ca	Mg	Al	Fe	Pb	Si	All Others	
Sun	12	4	118.2	12.62	0.81	2.03	1.25	0.37	3.24	0.29	20.62
Wed	12	7	282.3	9.95	0.98	4.77	3.93	0.57	2.34	0.78	23.32
Sun	24	5	130.8	9.75	0.76	3.00	1.22	0.23	3.21	0.41	18.59
Wed	24	5	268.7	9.77	1.13	5.43	1.88	0.61	2.38	0.62	21.82
Sun	28	3	133.6	8.87	0.58	2.73	0.40	0.20	1.91	0.32	15.03
Wed	28	7	178.3	9.44	0.97	3.05	1.72	0.25	1.34	0.31	17.09

To more clearly study the relationship between total weight of the elements to the weight of the sample, Figure 19 is presented. The percentage of the six elements and "all others" are graphically presented, as well as the total weights of the elements on Sundays and Wednesdays. As the total weights were considerably greater on Wednesdays than on Sundays, and as the total weight of the elements remained approximately the same, the elements when calculated in percentage to the total weight, showed a marked increase on Sundays over Wednesdays.

It may be seen that calcium was the major contributor to the total elements with silicon and aluminum contributing to a lesser degree. The percentage of iron was greater at Stations 12 and 28 on Wednesdays than on Sundays, whereas the percentage of lead remained approximately the same at these two stations.

It may therefore be concluded from the data presented in Table 14 and Figure 19, that at two of the three stations, the average total weight obtained on Wednesdays was appreciably greater than obtained on Sundays, whereas the average total weight of the elements remained rather constant. This increase in total weight was probably organic in nature and attributable to greater community activity.

FIGURE 19. Comparison of average total weight and elements in percentage of total weight for Sunday vs. Wednesday



Comparison of the Elements to Particulate Matter on Days of Light and Heavy Pollution

Table 15 presents the data obtained at four stations for total particulate matter, six elements, and "all others" on a day of light (August 22) and a day of heavy (September 11) pollution. The weight of Calcium at each of the four stations was greater on the day of light pollution than on the day of heavy pollution and the weight of aluminum was greater at all but one station on day of light pollution. Magnesium was greater on day of high pollution at Stations 1 and 4 and greater on day of low pollution at Stations 19 and 24. Iron, lead, silicon and the remaining sixteen elements were all greater on day of high pollution than day of low pollution.

The total weight of the twenty-two elements was greater on September 1 than on August 22 at Station 19 by 36 percent and at Station 24 the increase was 29 percent. However, at Stations 1 and 4 the total weight of the elements showed a decrease on the day of heaviest pollution. At Station 1 the decrease was 24 percent and at Station 4 the decrease was 21 percent.

Table 16 shows the relationship of the twenty-two elements in percentage to the total weight of the particulates at four stations on August 22 (light pollution) and September 11 (heavy pollution). These data are presented graphically in Figure 20.

At Station 1, calcium, magnesium and aluminum represented a much higher percentage of the total particulates on the day of light pollution than on the day of heavy pollution. The percentage of "other elements" was also higher on August 22 than on September 11. On August 22, 16 percent of the particulate matter was accounted for in the weight of the twenty-two elements, whereas on September 11, only 4 percent of the total weight of the particulate matter was accounted for in the weight of the twenty-two elements.

At Station 4, calcium, magnesium, aluminum and silicon represented a greater percentage of total weight on August 22 than the same elements on September 11, and the total weight of the twenty-two elements on August 22 was approximately three times the percentage of these elements on September 11.

At Station 19, calcium, magnesium, aluminum and iron were of higher percentages on August 22 than these same elements on September 11. The total percentage of the elements was approximately three times

TABLE 15. Comparison of samples collected at four stations on days of heavy (September 11) and light (August 22) particulate pollution in the Detroit area

Weights in Micrograms per cubic meter of air										
Date	Sta.	Total Weight	Ca.	Mg.	Al.	Fe.	Pb.	Si.	All Others	Total-22 Elements
Aug 22	1	182.7	10.97	3.29	10.97	1.73	0.08	1.65	0.39	29.38
Sept 11	1	529.7	2.01	1.08	6.02	6.02	0.80	4.82	1.57	22.32
Aug 22	4	186.7	14.53	2.18	10.90	2.72	0.18	1.09	0.54	32.14
Sept 11	4	419.1	6.72	1.01	6.72	6.72	0.67	2.02	1.58	25.43
Aug 22	19	140.8	6.51	0.75	3.25	2.44	0.10	0.88	0.48	14.32
Sept 11	19	620.9	5.68	1.02	2.84	3.79	0.47	4.54	1.15	19.49
Aug 22	24	60.6	14.26	0.68	2.25	1.36	0.18	0.82	0.27	19.65
Sept 11	24	538.7	7.28	1.64	7.28	2.73	0.73	4.37	0.88	24.91

Ratio of September 11 to August 22, 1952									
Station	Total Weight	Ca.	Mg.	Al.	Fe.	Pb.	Si.	All Others	Total-22 Elements
1	2.9	.18	.33	.55	3.4	10.0	2.9	4.0	.74
4	2.2	.45	.46	.62	2.4	3.7	1.9	2.9	.79
19	4.4	.87	1.46	.87	1.6	4.7	5.1	2.3	1.36
24	8.9	.51	2.41	3.24	2.0	4.1	5.3	3.3	1.27

greater on August 22 than on September 11.

At Station 24 on August 22, the lowest total weight was obtained for this presentation, 60.6 micrograms per cubic meter of air. Calcium accounted for 23.5 percent of this weight. Magnesium, aluminum, iron and silicon were in greater percentage on August 22 than on September 11. The total weight of the elements on August 22 was 32 percent of the total weight of the particulates, whereas on September 11 at this station, the total weight of the elements was only 4.6 percent of the total weight of the particulates.

These data indicated that the ratio of the weight of the elements analyzed to the total weight of the sample on days of light and heavy pollution showed that regardless of the variation in weight of sample, the quantities of the elements present were relatively constant. It is therefore apparent that constituents, other than those analyzed, are present in greater quantities when the pollution is high than when the pollution is low; in all probability these are organic constituents and carbon.

Relationship Between Period of Heavy Pollution to a Period of Light Pollution

During the investigation, on September 10, 11 and 12, higher than normal total air pollutants were observed at all stations, at which time there was an increase in infant and respiratory cancer mortality, lachrymation and other physiological complaints. It must be emphasized that our present knowledge does not permit the conclusion that these distressing effects were the results of the high pollution. It was, however, decided to study the composition of the particulates collected during this period in relationship to other selected days.

Table 17 reveals the total weight of the samples collected on September 10, 11, and 12 were considerably higher than those for the other selected days. Calcium was surprisingly uniform regardless of the total weight of the samples. Magnesium was also rather constant with the exception of the values on September 4 and the high value obtained on September 5, which were days of relatively low total pollution.

Magnesium on August 22 and a value of 1.41 micrograms per cubic meter of air, however, on September 11, although the total pollution had increased fourfold, the magnesium remained essentially the same.

TABLE 16. Relationship of elements in percentage to the total weight of particulate matter at four stations on August 22 and September 11, 1952

Date	Sta.	Total Weight	P E R C E N T A G E							Total-22 Elements
			Ca.	Mg.	Al.	Fe.	Pb.	Si.	All Others	
Aug 22	1	182.7	6.00	1.80	6.00	0.95	0.04	0.90	0.39	16.08
Sept 11	1	529.7	0.38	0.21	1.14	1.14	0.15	0.91	0.29	4.21
Aug 22	4	186.7	7.78	1.17	5.84	1.46	0.10	0.58	0.29	17.21
Sept 11	4	419.1	1.61	0.24	1.61	1.61	0.16	0.48	0.37	6.07
Aug 22	19	140.8	4.62	0.53	2.31	1.73	0.01	0.62	0.34	10.16
Sept 11	19	620.9	0.91	0.16	0.46	0.61	0.08	0.73	0.19	3.13
Aug 22	24	60.6	23.50	1.12	3.71	2.24	0.03	1.35	0.44	32.40
Sept 11	24	538.7	1.35	0.30	1.35	0.51	0.14	0.81	0.16	4.62

FIGURE 20. Comparison of day of light pollution to day of heavy pollution - August 22 and September 11, 1952

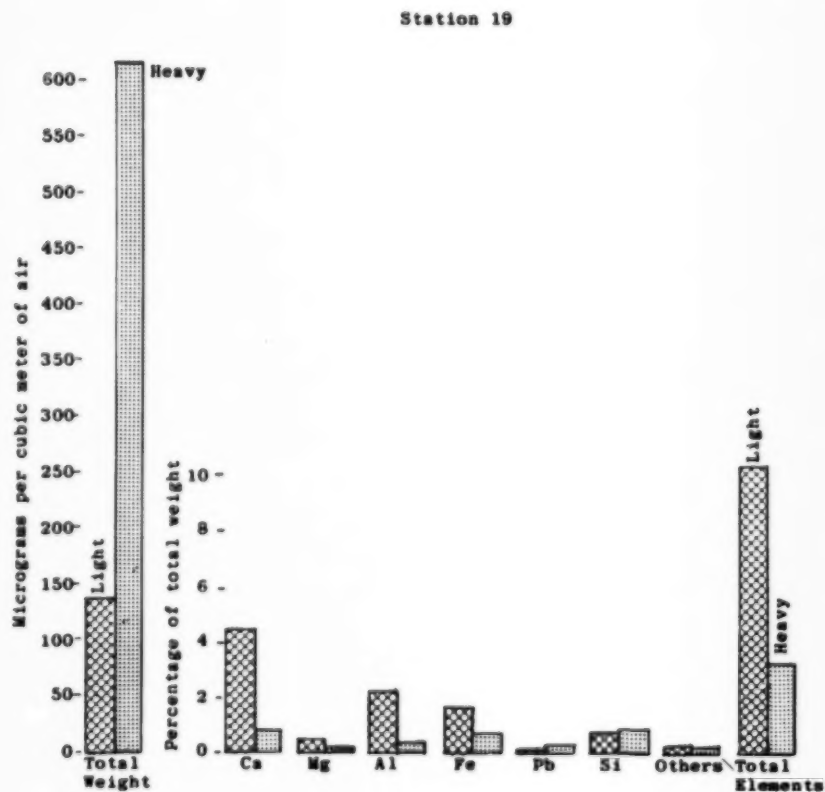
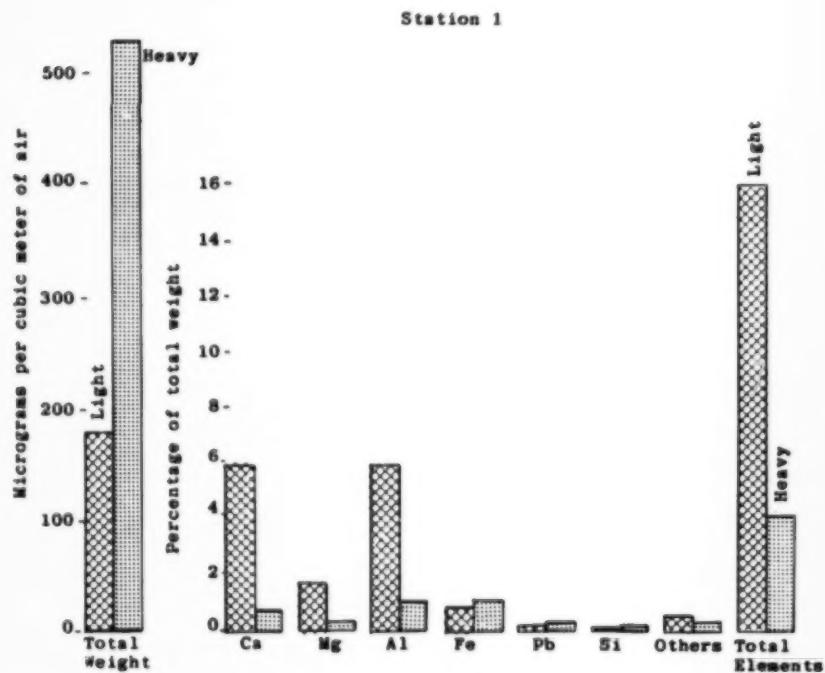


FIGURE 20 Continued

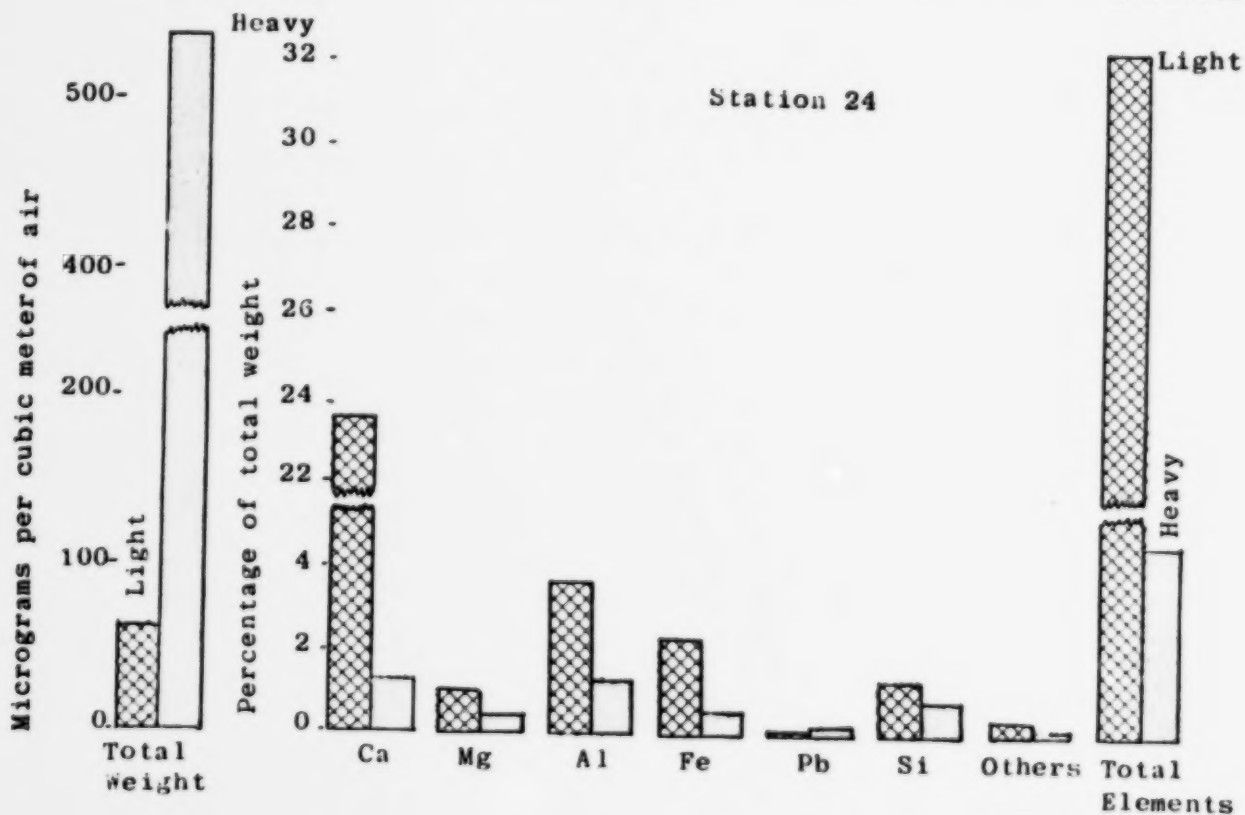
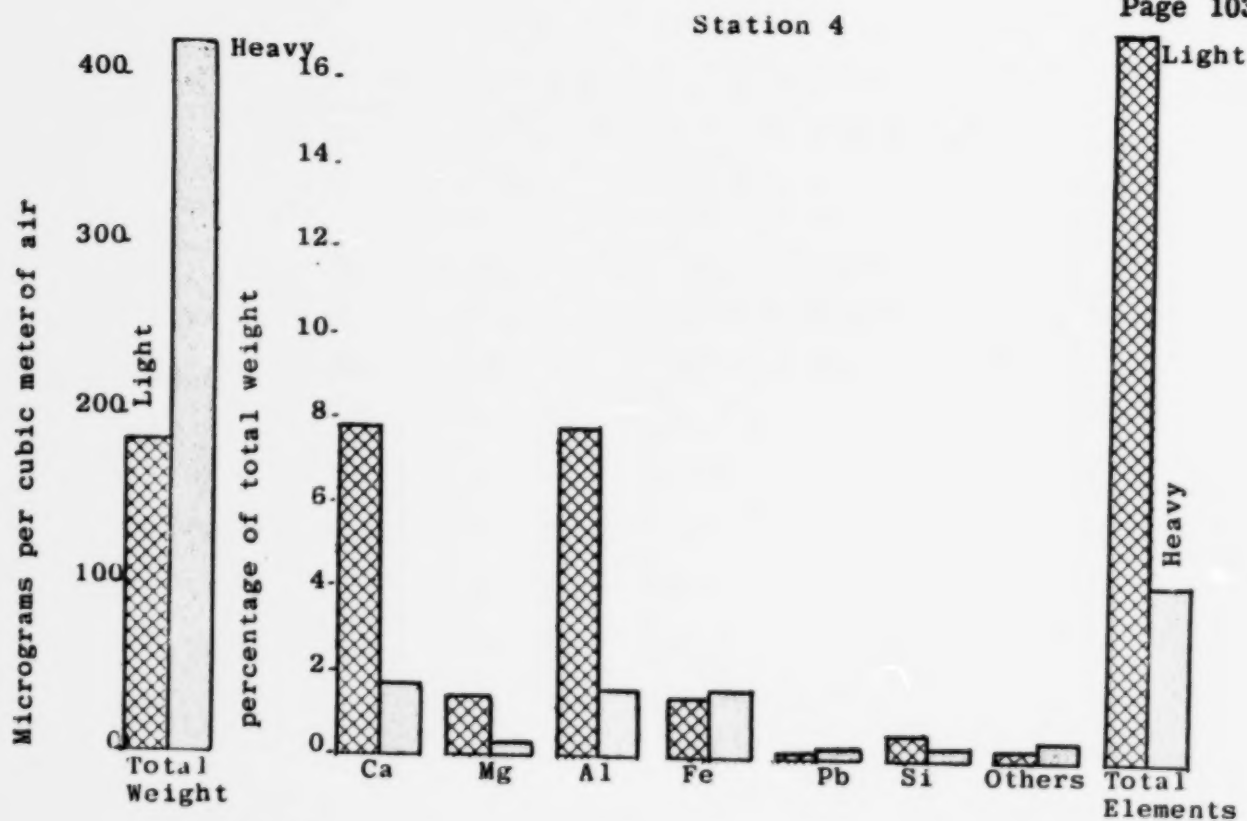


TABLE 17. Average weights, in micrograms per cubic meter of air, of total particulate matter and ten elements at all stations on selected days

DATE	Aug 22	Aug 28	Sept 4	Sept 5	Sept 10	Sept 11	Sept 12
TOTAL WEIGHT	142.1	304.3	168.3	299.1	404.2	521.6	528.4
ELEMENTS							
Calcium	10.13	7.97	8.45	10.30	11.48	9.30	12.99
Magnesium	1.41	1.37	0.67	2.23	1.39	1.42	1.26
Copper	0.04	0.24	0.04	0.18	0.13	0.12	0.04
Aluminum	6.62	9.48	2.08	14.20	3.81	5.59	4.91
Zinc	0.17	0.40	0.14	0.43	0.31	0.39	0.25
Molybdenum	0.03	0.04	0.03	0.07	0.03	0.05	0.06
Manganese	0.12	0.19	0.13	0.16	0.27	0.29	0.26
Iron	2.17	4.94	1.63	9.46	3.71	5.59	2.61
Lead	0.25	0.56	0.44	0.81	0.78	0.64	0.96
Silicon	1.02	1.45	1.83	2.16	5.93	4.39	5.24

FIGURE 21. Average data obtained from nine stations of total particulate matter and percentage of ten elements by selected dates

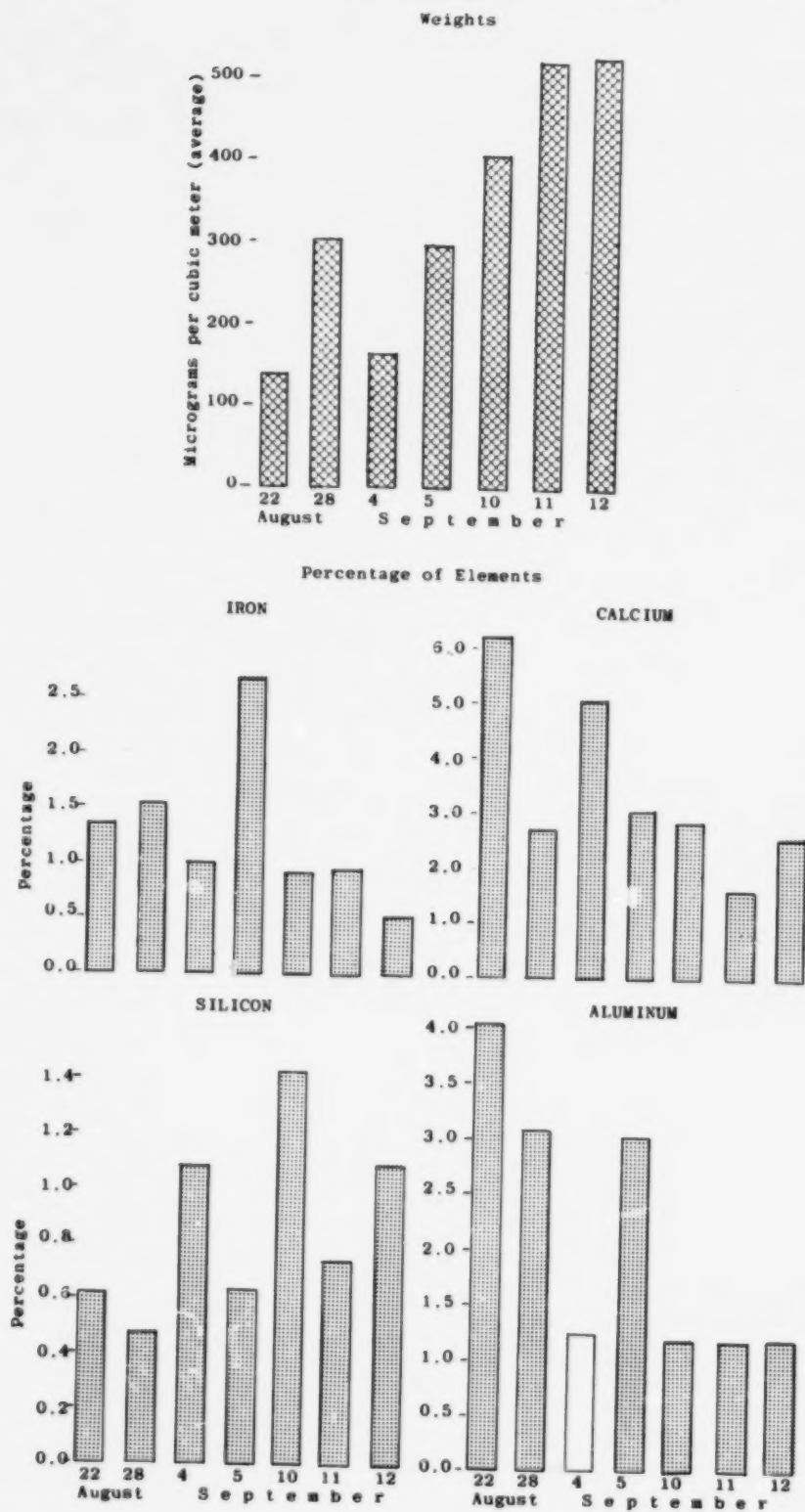
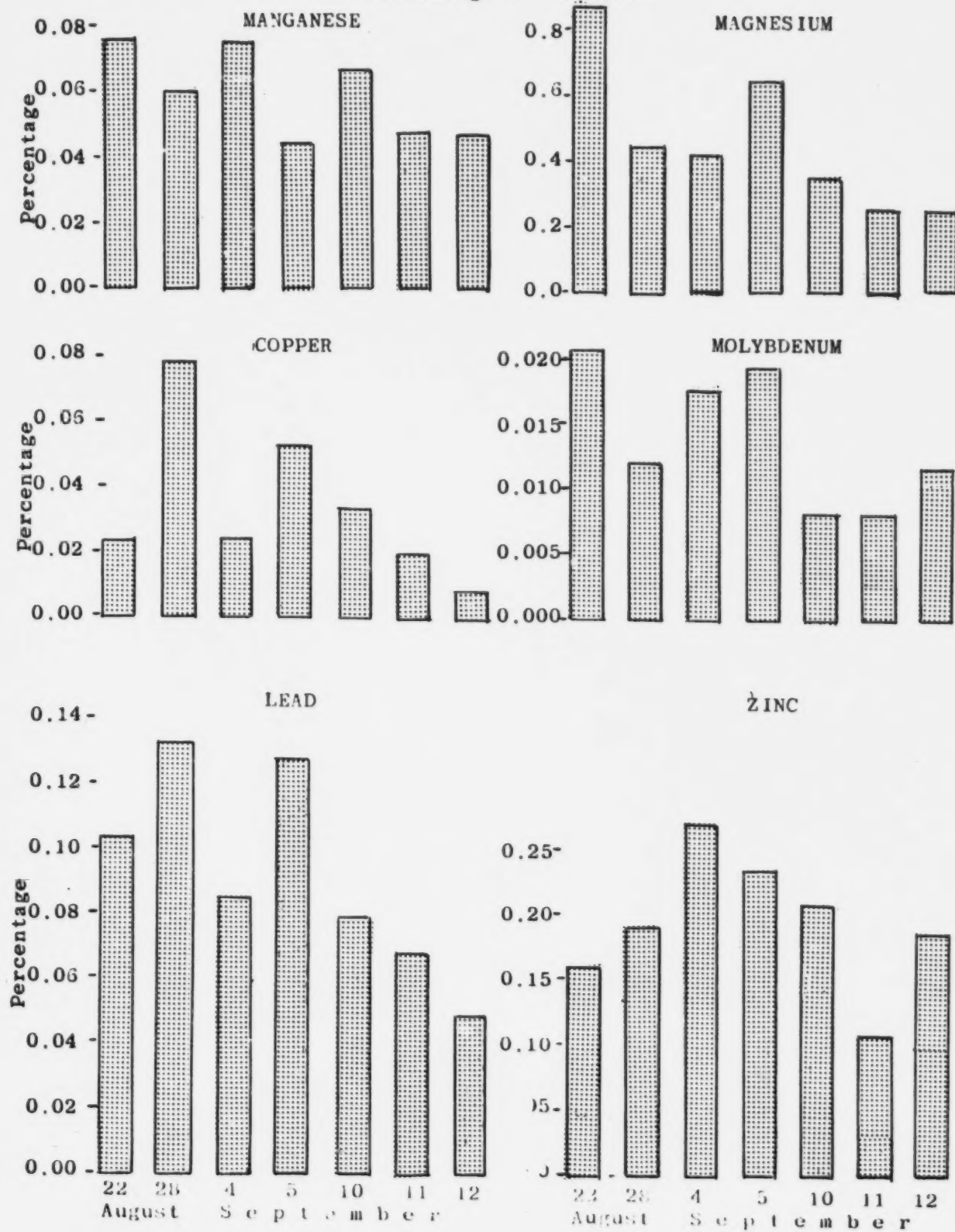


FIGURE 21. Continued

Percentage of Elements



Copper, aluminum, zinc, molybdenum, iron and lead did not increase during the period September 10, 11, and 12 when compared to the other selected days. Of special interest is that of the ten elements studied, only manganese and silicon showed an increase during the period of September 10, 11, and 12.

Figure 21 presents ten elements in percentage to the weight of the sample by day. The highest percentage values for aluminum, calcium, magnesium and molybdenum occurred on August 22, the day which had the lowest total weight.

On September 10, 11 and 12 the lowest percentage relationship between total weight and elements was found for seven of the ten elements (calcium, iron, aluminum, magnesium, copper, molybdenum and zinc). In comparing September 10, 11 and 12 to the other selected days by percentage, manganese was the only element having a higher value, which occurred on September 10.

These data reveal that none of the individual elements studied, sufficiently increased on September 10, 11 and 12 to cause the adverse effects that occurred during this high pollution period.

TRANSMISSIVITY

Measurement of light transmission as a means of evaluating air pollution was pursued experimentally in 1952. The measurements were made with a Transmissometer, the essentials of which have been previously described under the section entitled "Sampling Equipment".

In use, the instrument was found to be extremely sensitive to minor changes in light transmission. For the purpose of this report, only the data procured from August 7 to September 19 was considered.

The instrument was installed in late May with the light source located on the ninth floor of the J. L. Hudson Company and the receiving unit on the eighth floor of the Water Board Building. The distance between the two units was approximately two hundred and fifty meters. The instrument was operated continuously at this location until October 1, 1952, at which time it was moved to the offices at 1015 Majestic Building.

Weekly Visibility

Figure 22 graphically presents the weekly average light transmission in miles for the selected period. The first and last periods were for less than seven days. The average light transmission on August 7, 8 and 9 was low but increased steadily throughout the study period until the week of September 7th, during which there ensued a three day inversion with subsequent greatly reduced visibility. The last period of six days, after the inversion had dispersed, records the large increase in light transmission which occurred.

Visibility by Day of Week

Figure 23 graphically shows the average light transmission by day of week. There was a notable reduction in transmission beginning on Thursday and persisting through Friday and Saturday, with an appreciable increase on Sunday and Monday.

Table 18 presents the average weight of total particulates by day of week obtained at nine stations during the period August 7 through September 19, 1952 in the Detroit area. It may be observed in this table that the lowest average weight was obtained on Monday and gradually increased to 303.1 micrograms per cubic meter of air on Thursday. On Friday the values began a decline, reaching a low of 127.7 on Monday.

FIGURE 22. Weekly average Transmissometer readings for period August 7 to September 19, 1952

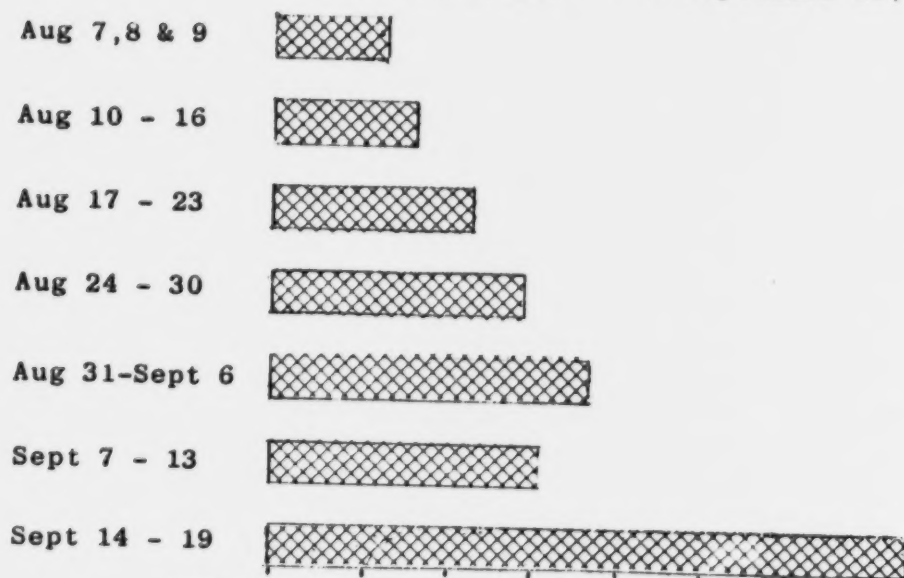


FIGURE 23. Daily average Transmissometer readings August 7 to September 19, 1952

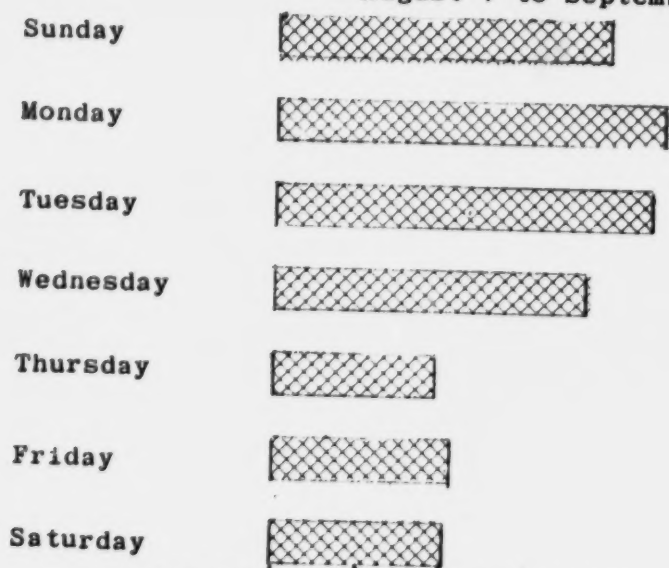


FIGURE 24. Average Transmissometer readings for selected periods

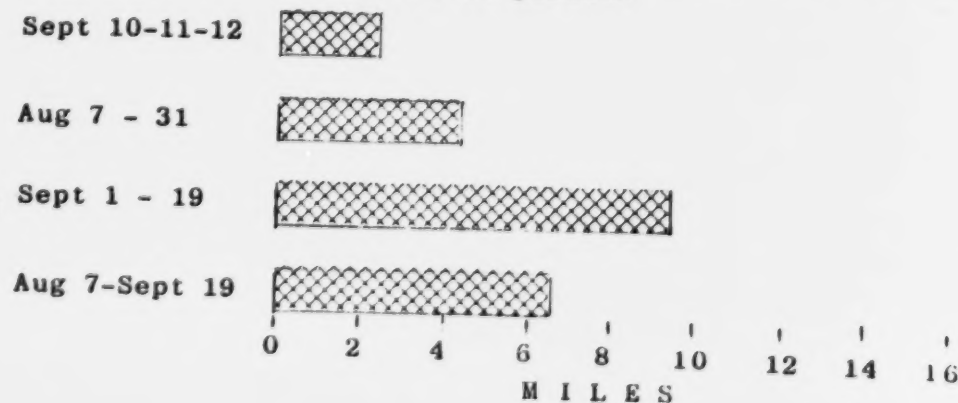


TABLE 18. Average weight of total particulates by day of week expressed in micrograms per cubic meter of air

<u>Sun.</u>	<u>Mon.</u>	<u>Tues.</u>	<u>Wed.</u>	<u>Thurs.</u>	<u>Fri.</u>	<u>Sat.</u>
198.5	127.7	256.6	290.7	303.1	286.4	234.4

Considering these total weight data were obtained at widely scattered locations in the City of Detroit and that the Transmissometer was located at one station several miles distant from the closest sampling area, the agreement between average Transmissometer readings and average total weight is believed sufficiently pertinent to require further evaluation of the instrument as a useful tool in studying air pollution.

Light Transmission for Selected Periods

Figure 24 shows the average light transmission for selected periods, the first of which is September 10, 11 and 12, the period of a three day temperature inversion. The second period represents average light transmission for that part of August covered by the survey, the third period, the average light transmission for that part of September studied which included September 10, 11 and 12, and the last period represents the average transmission in miles for the entire study period, August 7 to September 19. Figure 24 indicates that September showed a large increase in measured transmission over August, even though a three day inversion was included in the September data. The data obtained during September 10, 11 and 12 indicated that during these days the visibility was the lowest.

In Figure 25 the half hour averages for light transmission are plotted for the periods September 1 to 19 and August 7 to 31. The general characteristics of the two periods are similar with the diurnal variations clearly shown for each month. The transmissivity was the lowest at 7:00 a.m. during the period September 1 to 19, reaching the next lowest at 7:30 p.m. During August 7 to 31, transmissivity remained low from 6:00 to 8:00 a.m. and 7:30 to 8:00 p.m. The generally greater light transmission in September, as previously shown in Figure 24, is again shown here.

In Figure 26 half hour averages for the period September 1 through 19 and for the days September 10, 11 and 12 are presented. The three curves for September 10, 11 and 12 were consistently below the curve for September 1 through 19 for every hour of the day.

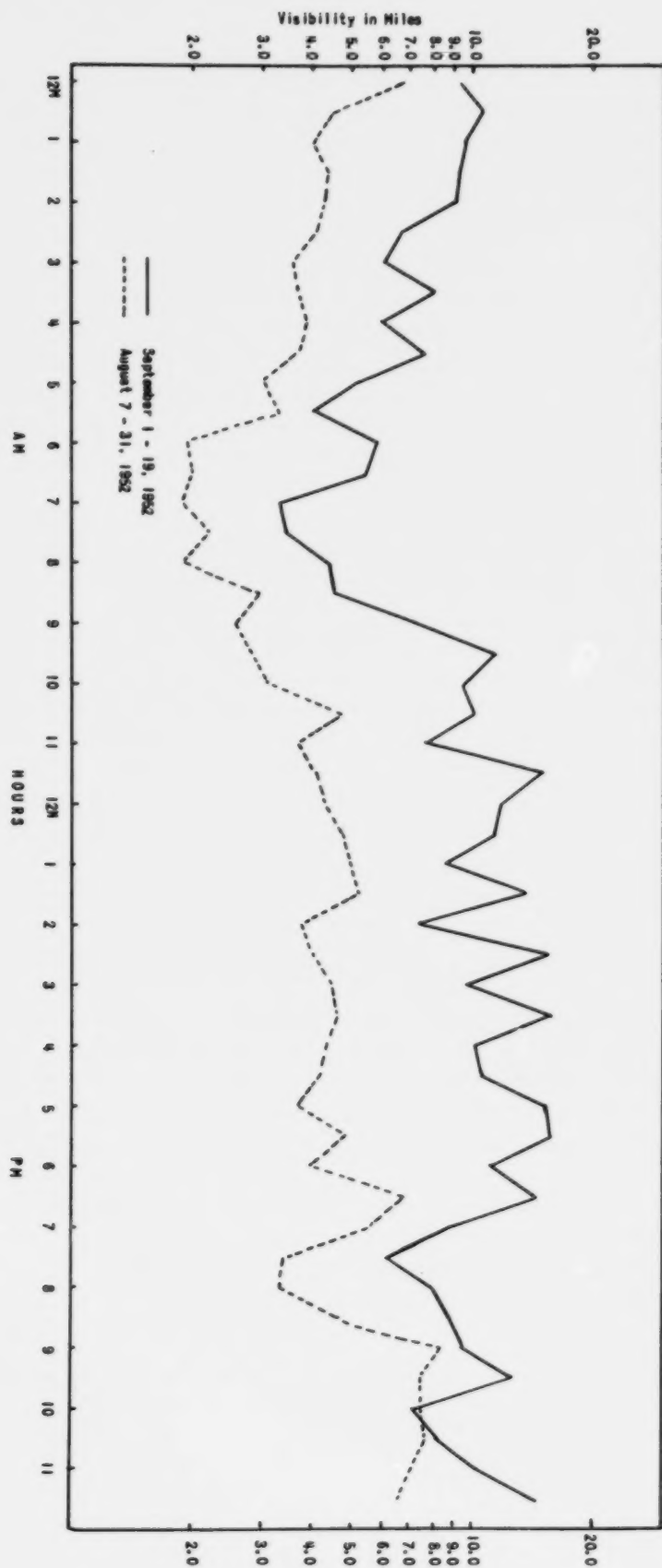


Figure 25. Half hour average values of light transmission for periods August 7 - 31, 1952 and September 1 - 19, 1952 in the downtown area of Detroit.

Visibility during September 10, 11 and 12 averages only 2.3 miles, approximately 7 miles less than the period September 1 through 19. Particulates collected during September 10, 11 and 12 averaged 485 micrograms per cubic meter of air which was approximately 230 more than for the period September 1 to 19.

The increased divergence of the curve noted between 6:30 a.m. and 9:00 a.m. records the effect of fog superimposed on the heavy particulate concentrations in the air. Records for Detroit City Airport show fog was present about 50 percent of the time between 6:30 a.m. and 9:00 a.m. on September 10, 11 and 12. During the remainder of the days, a pronounced haziness of the air, with low humidity, characterized the weather. No precipitation occurred during the three days.

With the exception of the interval 6:30 a.m. to 9:00 a.m., when fog accentuated the results, it is evident that heavy particulate pollution was the cause of the greatly reduced visibility.

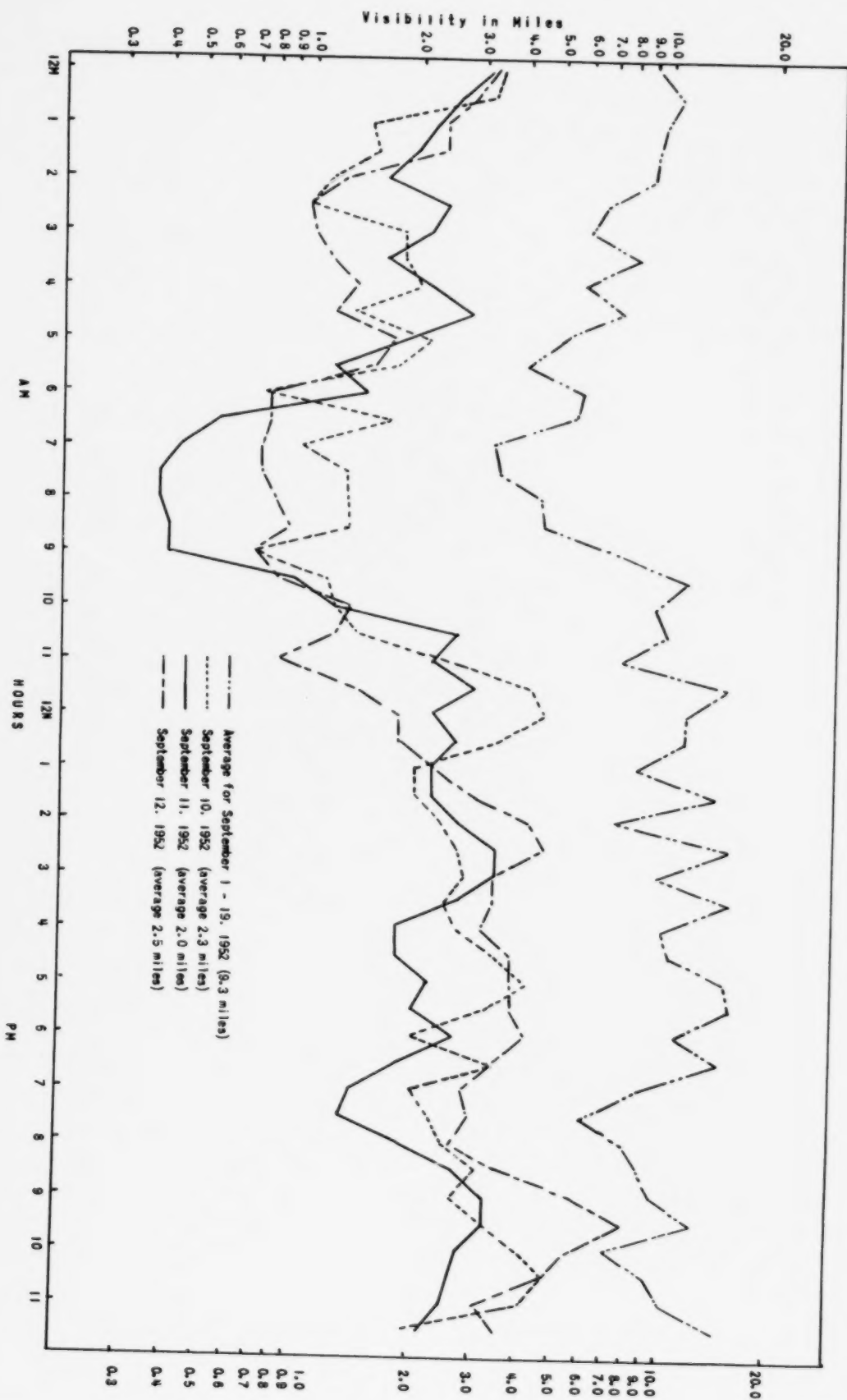
By September 15, the pollution had decreased to an average of 82 micrograms per cubic meter of air, well below the average, while light transmission increased to an average of 23.2 miles. The great reduction of particulate pollution and the resultant increase in light transmission was probably brought about by a cold front which moved through Detroit at 1:00 a.m. on the 15th. After the cold frontal passage, cleaner, cooler air flowed over the area from the northwest. For a more detailed discussion on the influence of cold frontal passages on air pollution, see page 143.

Relationship Between Visibility and Particulate Pollution

Figure 27 presents the daily average of total particulates at all stations and the reciprocal of the average daily light transmission. The reciprocal was used in order to more clearly illustrate the data. Except for three or four minor disconformities, similar instances of coincident tendencies are shown throughout the entire study period.

These data are again insufficient to clearly define the exact usefulness of the Transmissometer, however, the numerous incidents of agreement with well known methods of measuring air pollution warrant further evaluation of this instrument.

Figure 25. Visibility readings (in miles) for September 10, 11, and 12, 1952 and the average visibility readings for September 1 through 19, 1952 in the downtown area of Detroit.



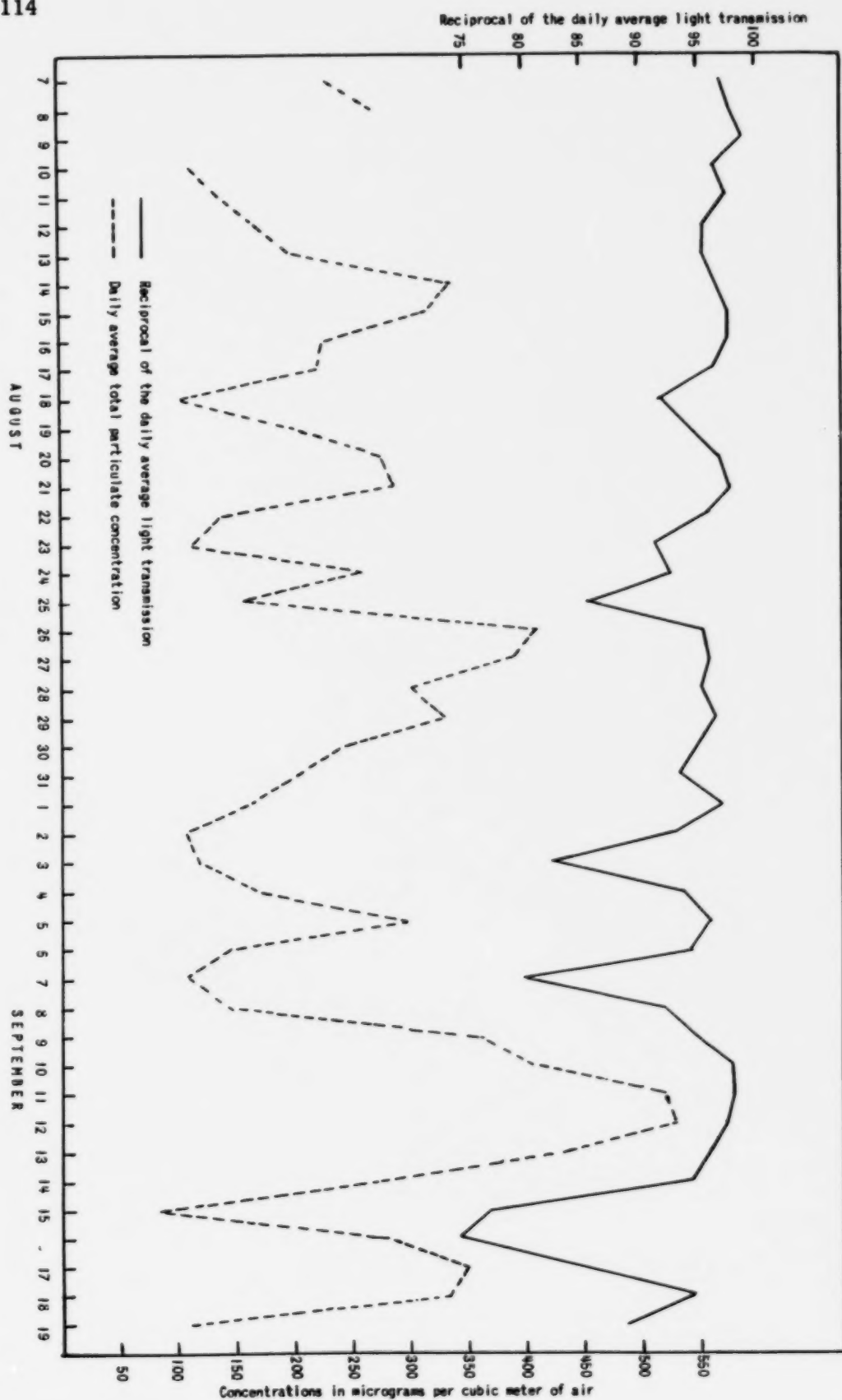
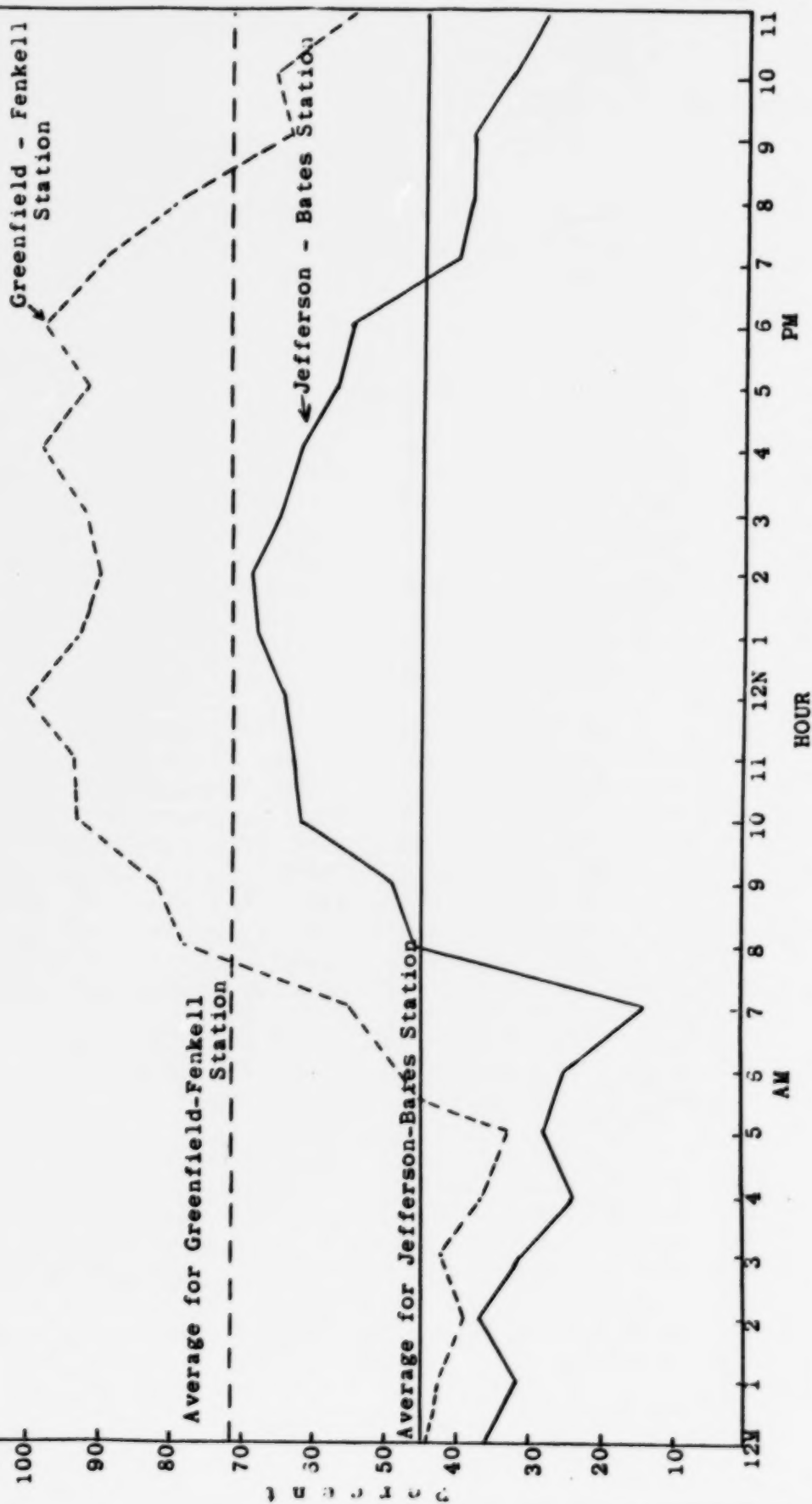


Figure 27. Comparison of the reciprocal of the daily average light transmission to the daily average concentration of total particulate matter of 9 stations for the period August 7 through September 19, 1952

FIGURE 28. Percentage of number of readings in the 0.5 shade (as determined by British Scale) obtained with the Owens Automatic Air Filter by time of day at Greenfield - Fenkell Station and Jefferson - Bates Station for the period May 15 through August 27, 1952.



FILTER PAPER TESTS

Samples were collected with the Owens Automatic Air Filter at two stations during the summer of 1952. The description of this instrument is given in the section entitled, "Sampling Equipment".

The British have prepared a standard scale of shades to be used in the interpretation of the automatic filter results. Through their experiments they have determined that each shade number correspond to 0.32 milligrams of particulates per cubic meter of air, on a basis of two liters of air per sample. Based upon these data, a measuring shade number of 0.5 represents 0.16 milligrams of particulates per cubic meter of air; 1.0 - 0.32; 2.0 - 0.64; 3.0 - 0.96; 4.0 - 1.28; 5.0 - 1.60; and 5.5 - 1.76 milligrams of particulates per cubic meter of air. It must be borne in mind, however, that these figures refer to the composition of particulates as found in the British Isles, the synthesis of which is probably not the same as those found in the City of Detroit. It is therefore impossible at this time to correctly interpret a weight factor from the shade number.

It is noted in Figure 28 that the average value at the Jefferson-Bates Station in downtown Detroit, showed much heavier shading than the average value for the Greenfield-Fenkell Station, which is about ten miles away in a relatively clean residential area. The two curves were quite similar, however, by hour of day. The smallest number of 0.5 shade at the Greenfield-Fenkell Station was recorded at 6:00 a.m., indicating the heaviest pollution occurred at this hour. The number of 0.5 shade rapidly increased and reached the largest number at 12:00 noon, indicating the highest pollution was recorded at this hour. Similar records were obtained at the Jefferson-Bates Station.

In Tables 19 and 20 are shown, by time of day, the frequency distribution of shadings (as determined by British Scale) for the Jefferson-Bates and the Greenfield-Fenkell Stations.

Tables 19 and 20 reveal that the shadings recorded at the Jefferson-Bates Station were considerably higher than those at the Greenfield-Fenkell Station. At the Greenfield-Fenkell Station the highest readings (3.0 shade) were recorded from 12:00 midnight to 7:00 a.m. After 7:00 a.m. the readings became considerably lighter, thus indicating that the heavier pollution at this station was in the early morning hours. At the Jefferson-Bates Station heavy pollution

readings of 5.5 were obtained. There were numerous readings in the relatively heavy grouping of 4.0 except for the hours from 8.00 a.m. to 4:00 p.m.

These data show that at both stations the period of lightest pollution was from 8:00 a.m. to 4:00 p.m. and the heaviest pollution was from the hours of 12:00 midnight to 7:00 a.m.

TABLE 19. Frequency distribution of hour shadings (as determined by British Scale) obtained with the Owens Automatic Air Filter at Jefferson - Bates Station for the period May 15 through August 27, 1952

Time of Day	SHADE							TOTAL
	0.5	1.0	2.0	3.0	4.0	5.0	5.5	
	Number							
12:00 M	55	29	46	20	0	0	0	150
1:00 AM	48	31	52	18	1	0	0	150
2:00	56	21	48	24	2	0	0	151
3:00	45	23	43	29	3	0	1	144
4:00	36	50	41	15	6	0	0	148
5:00	40	30	39	23	7	0	1	140
6:00	37	42	44	12	10	1	0	146
7:00	14	42	26	7	2	3	0	94
8:00	47	39	15	0	0	0	0	101
9:00	64	45	18	3	0	0	0	130
10:00	83	35	12	2	1	0	0	133
11:00	88	41	9	0	0	0	0	138
12:00 N	96	38	14	1	0	0	0	149
1:00 PM	106	40	7	2	0	0	0	155
2:00	106	29	17	2	0	0	0	154
3:00	99	31	16	4	1	0	1	152
4:00	93	35	18	3	0	0	0	149
5:00	87	34	21	5	2	0	0	149
6:00	83	43	18	4	1	0	0	149
7:00	65	62	22	6	1	0	1	157
8:00	61	59	28	9	1	0	1	158
9:00	60	49	29	13	4	0	0	155
10:00	52	47	48	6	4	0	0	157
11:00	45	50	47	7	9	0	0	158
TOTAL	1,566	945	678	215	55	4	4	3,467
Percent								
12:00 M	36.7	19.3	30.7	13.3	0	0	0	100.0
1:00 AM	32.0	20.7	34.7	12.0	0.6	0	0	100.0
2:00	37.1	13.9	31.8	15.9	1.3	0	0	100.0
3:00	31.3	16.0	29.9	20.1	2.0	0	0.7	100.0
4:00	24.3	33.8	27.7	10.1	4.1	0	0	100.0
5:00	28.6	21.4	27.9	16.4	5.0	0	0.7	100.0
6:00	25.3	28.8	30.1	8.2	6.9	0.7	0	100.0
7:00	14.9	44.7	27.7	7.4	2.1	3.2	0	100.0
8:00	46.5	38.6	14.9	0	0	0	0	100.0
9:00	49.2	34.6	13.9	2.3	0	0	0	100.0
10:00	62.4	26.3	9.0	1.5	0.8	0	0	100.0
11:00	63.8	29.7	6.5	0	0	0	0	100.0
12:00 N	64.4	25.5	9.4	0.7	0	0	0	100.0
1:00 PM	68.4	25.8	4.5	1.3	0	0	0	100.0
2:00	68.9	18.8	11.0	1.3	0	0	0	100.0
3:00	65.1	20.4	10.5	2.6	0.7	0	0.7	100.0
4:00	62.4	23.5	12.1	2.0	0	0	0	100.0
5:00	58.4	22.8	14.1	3.4	1.3	0	0	100.0
6:00	55.7	28.9	12.1	2.7	0.6	0	0	100.0
7:00	41.4	39.6	14.0	3.8	0.6	0	0.6	100.0
8:00	38.6	37.4	17.7	5.7	0.6	0	0	100.0
9:00	38.7	31.6	18.7	8.4	2.6	0	0	100.0
10:00	33.1	29.9	30.6	3.8	2.6	0	0	100.0
11:00	28.5	31.6	29.8	4.4	5.7	0	0	100.0

TABLE 20. Frequency distribution of hour shadings (as determined by British Scale) obtained with the Owens Automatic Air Filter at Greenfield-Fenkell Station for the period May 15, through August 27, 1952

Time of Day	SHADE				
	0.5	1.0	2.0	3.0	TOTAL
	Number				
12:00 M	23	17	6	6	52
1:00 AM	21	16,	8	4	49
2:00	19	9	12	3	43
3:00	21	17	6	6	50
4:00	18	15	9	7	49
5:00	14	16	5	7	42
6:00	12	19	6	8	45
7:00	26	12	7	2	47
8:00	44	9	3	0	56
9:00	46	10	0	0	56
10:00	44	3	0	0	47
11:00	46	3	0	0	49
12:00 N	58	0	0	0	58
1:00 PM	55	3	1	0	59
2:00	49	4	1	0	54
3:00	50	3	1	0	54
4:00	54	1	0	0	55
5:00	45	4	0	0	49
6:00	48	1	0	0	49
7:00	47	3	2	0	52
8:00	42	7	4	0	53
9:00	37	14	7	0	58
10:00	33	10	7	0	50
11:00	29	13	10	1	53
TOTAL	881	209	95	44	1,229
Percent					
12:00 M	44.3	32.7	11.5	11.5	100.0
1:00 AM	42.9	32.7	16.3	8.1	100.0
2:00	44.2	20.9	27.9	7.0	100.0
3:00	42.0	34.0	12.0	12.0	100.0
4:00	36.7	30.6	18.4	14.3	100.0
5:00	33.3	38.1	11.9	16.7	100.0
6:00	26.7	42.2	13.3	17.8	100.0
7:00	55.3	25.5	14.9	4.3	100.0
8:00	78.6	16.1	5.3	0	100.0
9:00	82.1	17.9	0	0	100.0
10:00	93.6	6.4	0	0	100.0
11:00	93.9	6.1	0	0	100.0
12:00 N	100.0	0	0	0	100.0
1:00 PM	93.2	5.1	1.7	0	100.0
2:00	90.7	7.4	1.9	0	100.0
3:00	92.6	5.5	1.9	0	100.0
4:00	98.2	1.8	0	0	100.0
5:00	91.8	8.2	0	0	100.0
6:00	98.0	2.0	0	0	100.0
7:00	90.4	5.8	3.8	0	100.0
8:00	79.2	13.2	7.6	0	100.0
9:00	63.8	24.1	12.1	0	100.0
10:00	66.0	20.0	14.0	0	100.0
11:00	54.7	24.5	18.9	1.9	100.0

SULFUR DIOXIDE

Evaluations of sulfur dioxide concentrations in the atmosphere were made with the Thomas Autometer. Two identical models of the instrument; one belonging to the City of Detroit and the other to the International Joint Commission, were operated at numerous sampling stations throughout the year.

Results Obtained with the International Joint Commission's Autometer Frequency Distribution.

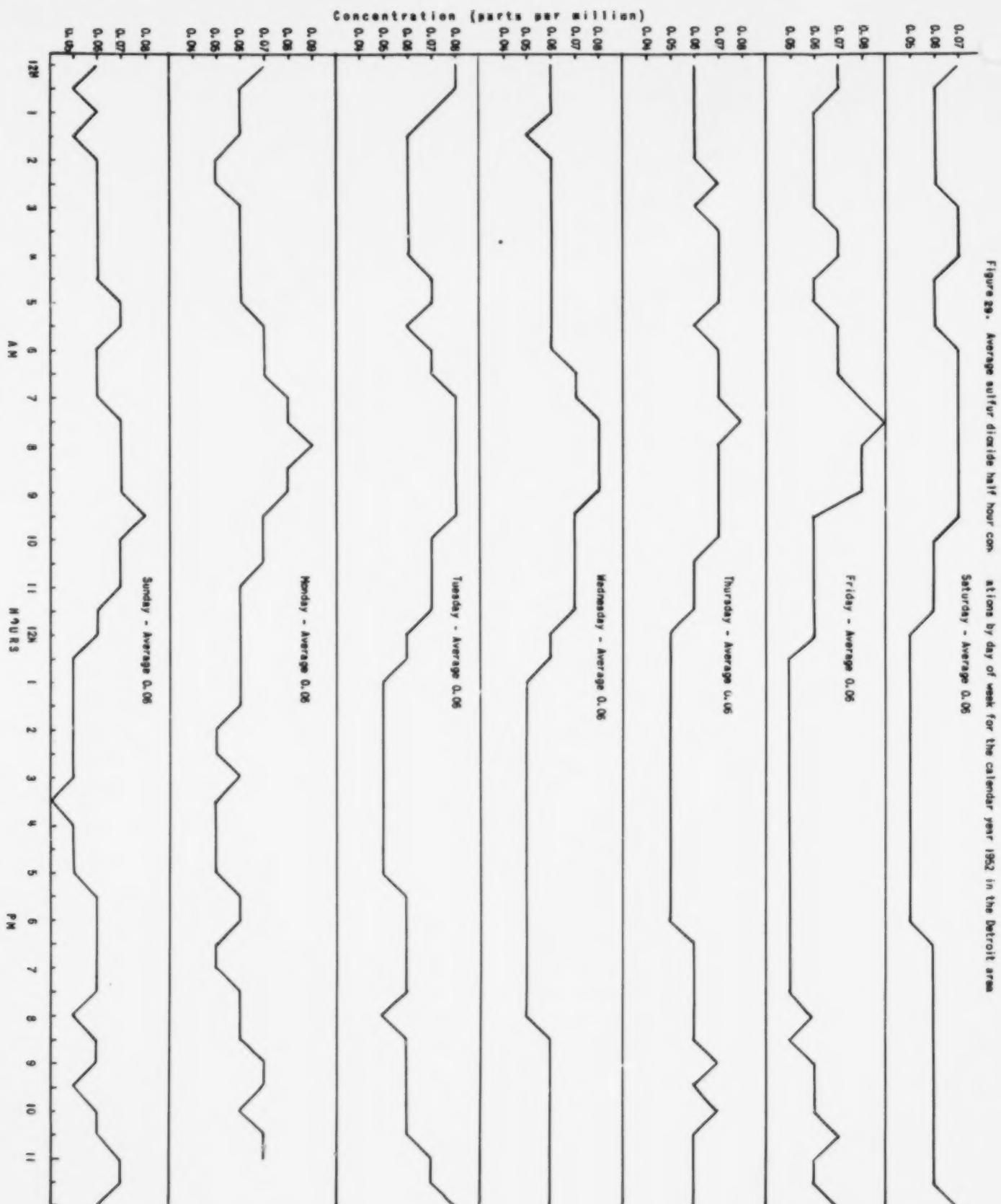
Table 21 shows the frequency distribution of the Thomas Autometer half hour average readings during the year 1952 (except October) by number of readings and percentage as compared to similar data collected from March 11 to December 17, 1951. Percentage values for the two years were in remarkably close agreement in all concentration ranges, thus indicating that the sulfur dioxide concentrations, as well as total particulates collected and the twenty-two elements, remained uniform from one year to the next in the Detroit atmosphere.

Daily Records

Figure 29 shows average half hour sulfur dioxide concentrations by day of week for the calendar year 1952. The average for each day was 0.06 parts per million. This indicates that industries which either ceased or reduced operations on Saturday and Sunday had no effect upon sulfur dioxide concentrations. It was noted that there was a slight increase in sulfur dioxide each forenoon, with subsequent lowering in the afternoon and a slight rise again in the early evening. The pattern for each day was very similar.

TABLE 21. Distribution of the frequency of Thomas Autometer half hour average readings (calculated as SO₂) recorded in Detroit for the Calendar years 1952 and 1951.

Concentration Range	Number		Percent	
	1952	1951	1952	1951
0.00 - 0.05	7,038	3,637	57	55
0.06 - 0.10	3,535	1,954	28	29
0.11 - 0.15	1,331	656	11	10
0.16 - 0.20	394	276	3	4
0.21 & over	160	175	1	2
TOTAL	12,458	6,698	100	100



Monthly Records

Figure 30 shows the average readings of sulfur dioxide concentrations by the month, for all months in 1952, except October, during which time the instrument was out of operation. This figure reveals that December had the highest average sulfur dioxide recording of 0.11 ppm. During June and July the lowest average monthly sulfur dioxide readings were obtained; each with an average value of 0.02 ppm.

Figure 30 also shows that the average sulfur dioxide reading for the year was 0.06 ppm with the concentrations varying from 0.05 to 0.08 ppm. The diurnal variations were again illustrated in this figure.

Peak Sulfur Dioxide Concentrations

In Table 22 percentages of sulfur dioxide peak occurrences are grouped by four hour periods. It may be noted that 21.3 percent of the peaks occurred between 12:00 midnight and 3:59 a.m., 18.5 percent between 4:00 a.m. and 7:59 a.m., and the smallest number of peaks occurred between 4:00 p.m. and 7:59 p.m. All other periods showed a similar percentage of peaks.

TABLE 22. Percentage of peak sulfur dioxide concentrations by selected periods of day recorded during 1952

PERIODS	PERCENTAGE
12:00M to 3:59 AM	21.3
4:00 to 7:59	18.5
8:00 to 11:59	16.4
12:00N to 3:59 PM	17.1
4:00 to 7:59	10.6
8:00 to 11:59	16.2

Figure 30. Monthly average su dioxin concentrations by half hour for the year 1952

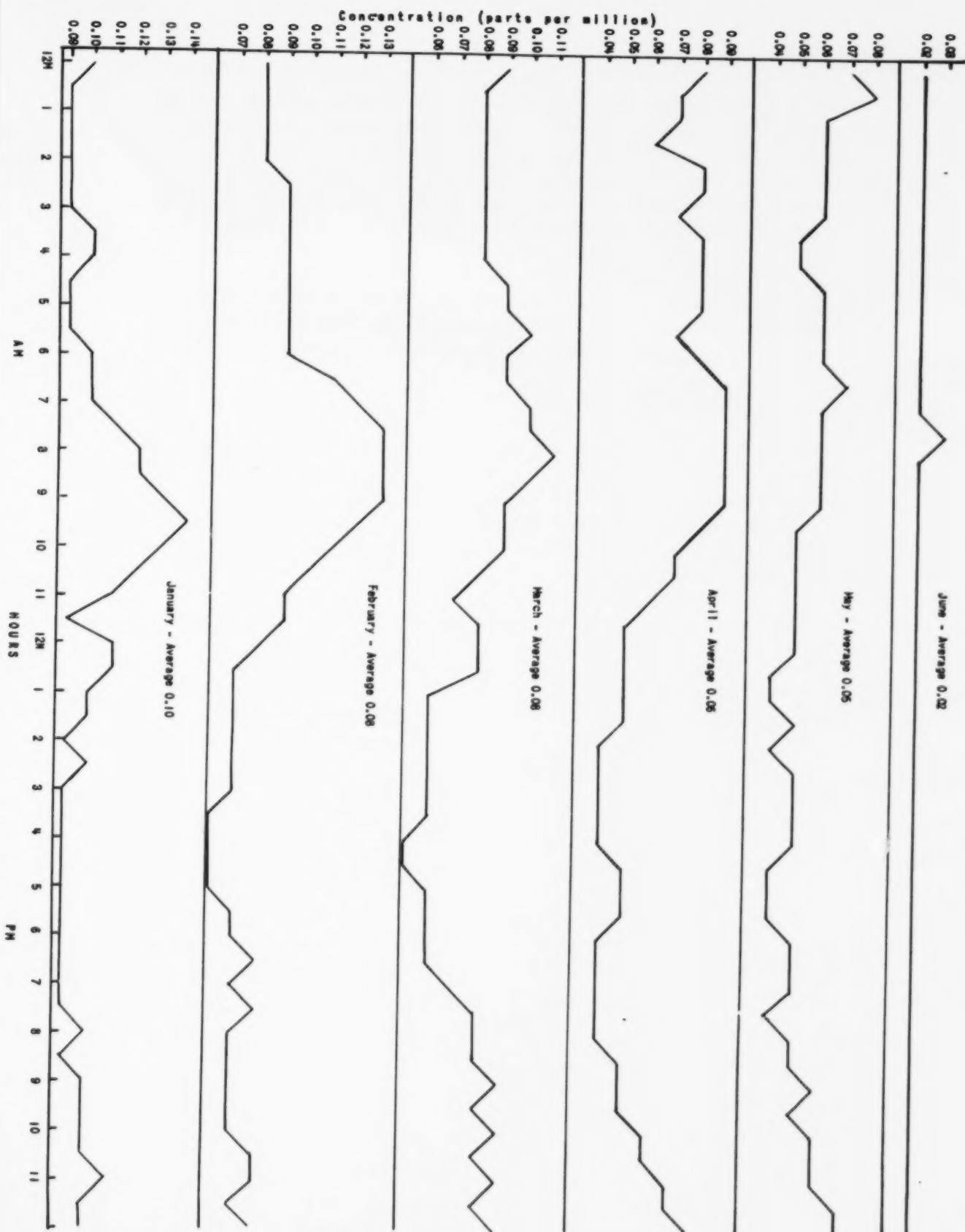
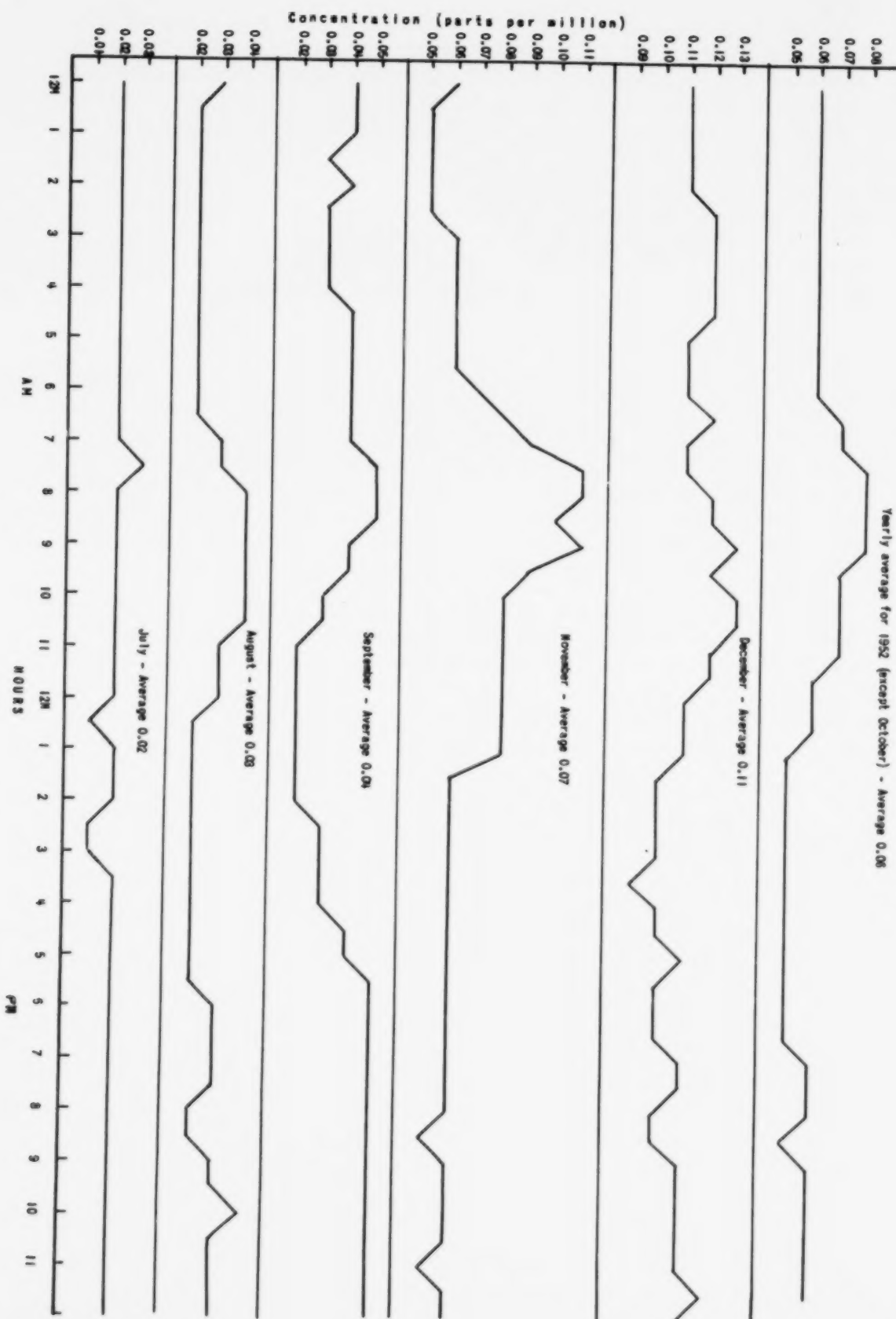


Figure 30. Continued



In January, sulfur dioxide concentrations reached a momentary high of 1.12 ppm. Several readings were obtained in the concentration range of 0.60 to 0.95 ppm. In February, the highest reading obtained was 1.06 ppm, with many readings in the 0.40 to 0.80 ppm concentration range. In March the highest reading recorded was 1.10 ppm, with several readings of 0.30 to 0.50 ppm. In April the highest concentration obtained was 1.39 ppm, with a few readings in the 0.40 to 0.60 ppm range. In May the highest reading was 2.30 ppm. In June the highest reading was 0.95 ppm. A high of 2.40 ppm was recorded in July and 2.30 ppm in August. September's high concentration was 1.04 ppm. In November and December there were readings ranging from 0.20 to 0.80 ppm.

Sulfur Dioxide Records by Station

Figure 31 shows the mean concentration of sulfur dioxide according to the time of day at each of the sampling stations for the year 1952. It is noted that the general trend of the averages from January through April was quite similar regardless of station, with the highest reading being recorded between 6:00 a.m. and 10:00 a.m. During the months of June, July and August, the trends, irrespective of station, were also similar in their lack of any great deviations and low concentrations.

In studying the data obtained at Station 11 during the periods January 11 to 31 and July 25 to August 31, it may be seen that there was considerable difference between the two sets of data. These data indicate that sulfur dioxide concentrations obtained at any one station may be influenced by the season of the year.

FIGURE 31. Mean concentrations (parts per million) of sulfur dioxide according to time of day, date and station.

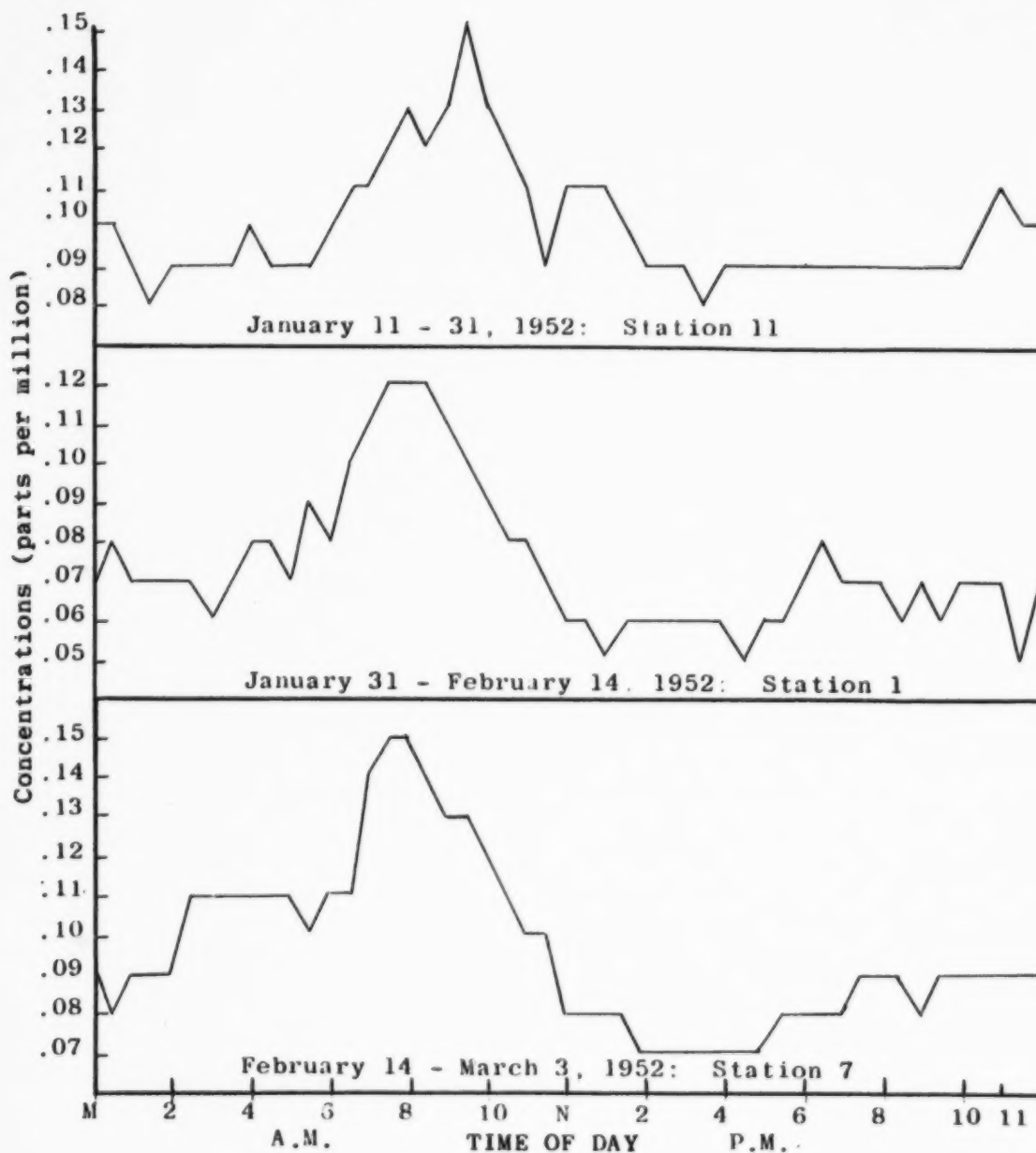
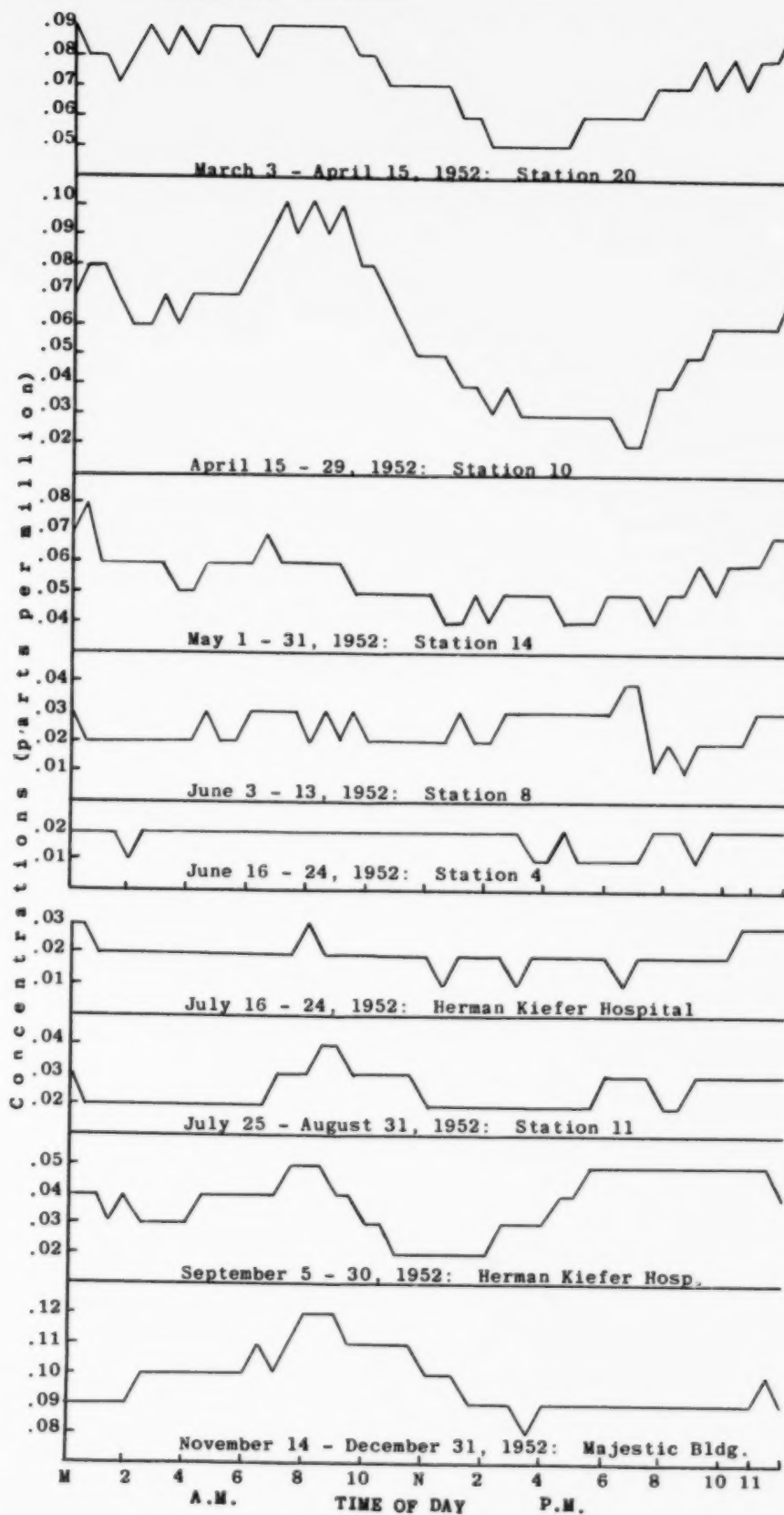


FIGURE 31. Continued



Results Obtained with City of Detroit's Autometer

The City of Detroit operated a Thomas Autometer at different stations within the study area. There was a well defined pattern established for both of the Autometers so that the maximum coverage of the area could be obtained.

Frequency Distribution

Table 23 presents the frequency distribution of half hour sulfur dioxide readings obtained with the City's Autometer during the period July 1 to December 22, 1952. Considering the different locations of the City's Autometer and the International Joint Commission's Autometer, and also considering the fact that the City's Autometer data was only for the period July 1 to December 22, 1952, there was good agreement between the results obtained with these instruments. The City's Autometer recorded 99 percent of the sulfur dioxide concentrations in the 0.0 to 0.15 ppm range, whereas the International Joint Commission's Autometer recorded 96 percent within that same range.

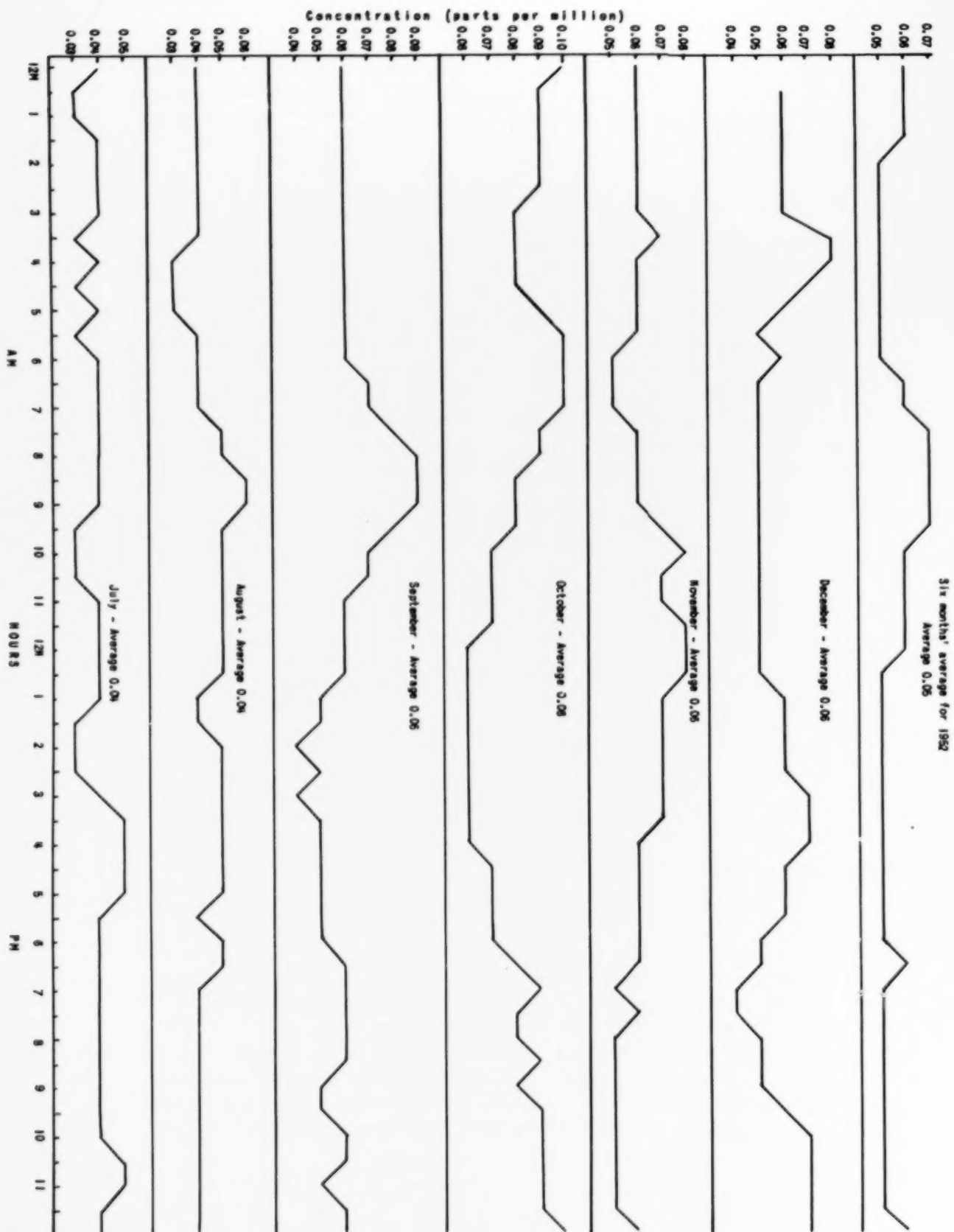
TABLE 23. Frequency distribution of City of Detroit's Thomas Autometer half hour average readings

Concentration Range	Number	Percent
0.00 - 0.05	2524	67.5
0.06 - 0.10	1006	26.9
0.11 - 0.15	176	4.7
0.16 - 0.20	32	0.85
0.21 & over	2	0.05

Monthly Records

Figure 32 presents the data obtained with the City's Autometer by month for the period July 1 through December 22, 1952. A comparison of this figure to Figure 30 reveals that the City's Autometer for July, August, and September had slightly higher concentrations than those recorded by the International Joint Commission's Autometer, recording values of 0.04, 0.04, 0.06, and 0.02, 0.03, and 0.04 ppm respectively. The greatest difference recorded between these instruments was during the month of December when the City's Autometer recorded 0.06 ppm and the International Joint Commission's Autometer recorded 0.11 ppm.

Figure 32. City of Detroit Automobile monthly average sulfur dioxide concentrations by half hour for six months in 1952



METEOROLOGY

The evaluation of the influence of meteorology upon air pollution by particulates was based mainly on daily surface weather reports for Detroit City Airport. The four radio soundings taken daily at Selfridge Air Force Base, Mount Clemens, Michigan, were also used as an indication of stability, from August 24 to September 18, 1952.

The collection of total particulates during the period August 7 through September 18, 1952 was conducted seven days a week at two stations in Windsor, and five days a week at eight stations. In Detroit the collection was conducted continuously at three stations and four days a week at six stations. It would have simplified the meteorological study if all stations had been operating each day of the week, as it is desirable to base the meteorological correlations on total particulates averaged from as many stations as possible. For this reason the data of eight stations in Windsor and nine stations in Detroit were combined and averaged.

In order to complete the record of pollution data for weekends, a lengthy series of computations were made, the details of which appear in Appendix I. This provided estimates for the weekends based on the results obtained from the three sampling stations which were operated, and the observed relationship between these three stations and all the stations.

Table 24 presents the basic total particulate concentrations and meteorological parameters used in this meteorological presentation.

TABLE 24. Mean total particulate pollution obtained from 19 stations in Detroit-Windsor area for the period August 8 to September 18, 1952 and pertinent meteorological data for the same period

Date	Total Particulates Micrograms/cubic meter		Mean Surface Wind Mi/hr	Tsfc-T850 Mt Clemens Centigrade	Surface Temp	
	Mean	Running Mean			Anomaly Fahrenheit	
Aug 8	192	-	6.0	-	+ 2	
9	-	174	8.8	-	+ 4	
10	96	144	11.8	-	+ 4	
11	183	148	6.1	-	- 3	
12	132	160	5.8	-	- 3	
13	192	189	4.8	-	- 3	
14	241	230	8.1	-	+ 5	
15	248	235	6.9	-	+ 10	
16	202	207	8.1	-	+ 8	
17	176	-	8.4	-	+ 3	
18	-	-	9.3	-	+ 3	
19	190	-	4.7	-	0	
20	215	214	7.0	-	+ 3	
21	235	196	11.0	-	+ 7	
22	100	142	12.0	-	- 7	
23	131	154	5.7	-	- 8	
24	256	217	4.4	7	- 5	
25	224	265	6.5	5	+ 4	
26	356	320	4.7	5	+ 5	
27	344	335	5.1	5	+ 8	
28	296	310	6.2	6	+ 10	
29	302	273	5.8	6	+ 10	
30	191	227	8.3	8	+ 9	
31	224	206	8.2	8	+ 14	
Sept 1	184	184	8.4	8	+ 14	
2	146	150	11.4	8	- 2	
3	126	144	12.4	8	- 7	
4	180	189	7.5	6	- 1	
5	271	240	8.3	6	+ 3	
6	240	217	10.7	4	- 1	
7	116	154	9.5	5	- 6	
8	146	186	5.3	2	- 4	
9	338	307	4.7	2	+ 7	
10	407	416	4.8	1	+ 12	
11	511	474	3.8	1	+ 14	
12	469	472	5.2	1	+ 15	
13	441	404	4.8	5	+ 17	
14	266	266	9.8	7	+ 14	
15	92	181	13.9	10	+ 7	
16	275	241	13.1	9	+ 2	
17	321	282	6.8	7	+ 2	
18	213	-	10.0	8	+ 2	

Daily Mean Concentrations of Particulate Pollution

Figure 33 depicts the daily averages of total particulates for Detroit and Windsor. It may be seen that the principal trends were similar in Windsor and Detroit, with the Detroit curve usually showing higher concentrations than those in Windsor.

Figure 34 shows the relationship of the combined total particulate concentration mean curve, and the running mean curve for Detroit and Windsor.

Diffusion of Air Pollutants

The role of meteorology in air pollution is based on the diffusion mechanism. Elaborate diffusion equations have been developed for idealized conditions of single sources of constant shape, location, and strength. Although these equations cannot be used directly in the complex problem posed by the Detroit-Windsor area, they indicate generally which meteorological factors are important in the dispersal of contaminants in the air.

These equations indicate that the concentration of pollution is inversely related to the mean surface wind speed and directly related to the stability of the atmosphere. To elaborate, the greater the lapse rate, the more vigorous is the turbulence; the more vigorous the turbulence, the more rapid the diffusion. Hence high pollution is associated with small lapse rates, (i.e. stable air) , and low pollution with large lapse rates, (i.e. unstable air)..

Some other features of the influence of meteorology upon air pollution which are not so directly related to diffusion are: influence of changing wind direction, the synoptic weather situations characteristic of high pollution and low pollution, the effect of cold frontal passages, and the influence of rainfall.

Mean Wind Speed and its Effect on Pollution

The mean surface wind speed at Detroit City Airport is shown in Table 24 for each day of the six weeks' study. These data and all other meteorological data, except where otherwise noted, were for the twenty-four hours beginning at 0001 Eastern Standard Time of the date shown. Pollution data were for the twenty-four hours ending at noon of the date shown. Since this difference in phase introduces no bias, as long as data for several days were considered together, it would not obscure the results.

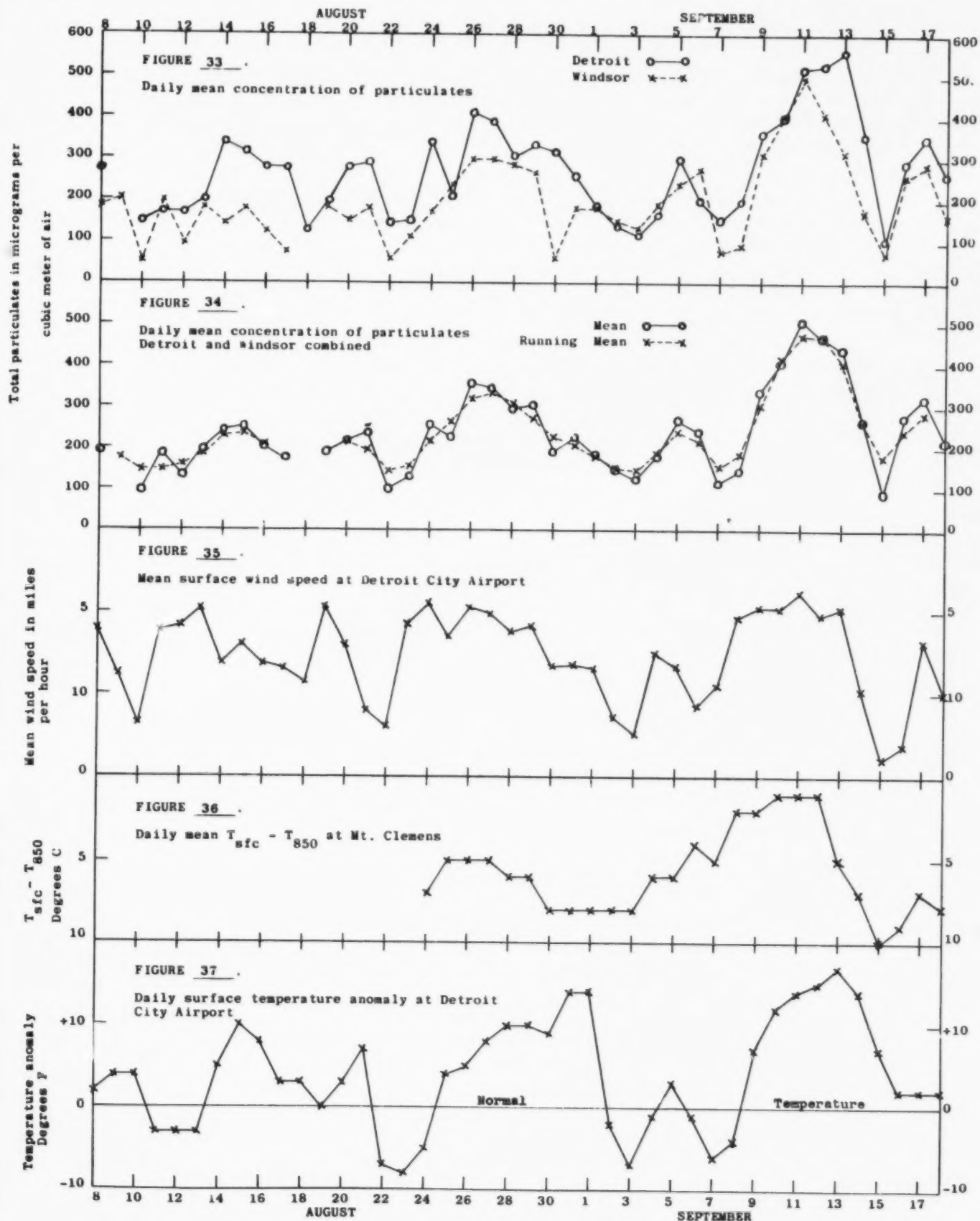


Figure 35 shows the day to day variations of the mean surface wind speed and a scale which was inverted to yield in-phase curves out of an inverse relationship. A study of this figure and Figure 34 shows that the two high pollution periods were associated with light winds. Conversely, the reduction of pollution was associated with increasing wind speed.

This relationship was studied further in Figure 38. The curved line confirmed the inverse rule of low pollution with high wind speeds, and high pollution with low wind speeds.

Since high pollution occurred only with light winds, whereas low pollution occurred with strong and light winds, it may be assumed that low surface wind speed is one requisite for high pollution.

Stability versus Pollution

To observe the relationship between air pollution and stability some satisfactory index of stability must be selected. Because it was readily available from the four daily radio soundings at Selfridge Field Air Force Base, Mt. Clemens, the mean daily temperature difference between the surface and 850 millibars was tested as a possible stability index. This defined a layer of air about 4000 feet thick.

During a one year trial it has proven to be a good index of low level stability. The quantity was found to range between extremes of 3 degrees C for very stable air, and 11 degrees C for very unstable air, but usually it ranged between 0 and 10 degrees C. It is therefore used in this discussion as a stability index.

Unfortunately the radiosonde program at Mount Clemens was inoperative for the first sixteen days of the six weeks' study. In order to provide an interim stability index for these sixteen days, another parameter, surface temperature anomaly, was introduced.

A good general rule of meteorology is that cold air masses in the Great Lakes region exhibit greater low level instability than warm air masses. The surface temperature anomaly is then an index to surface layer stability. Above normal temperatures might be expected to indicate stability, and below normal temperatures might be expected to indicate instability. The monthly climatological summaries for Detroit City Airport include the daily temperature anomaly.

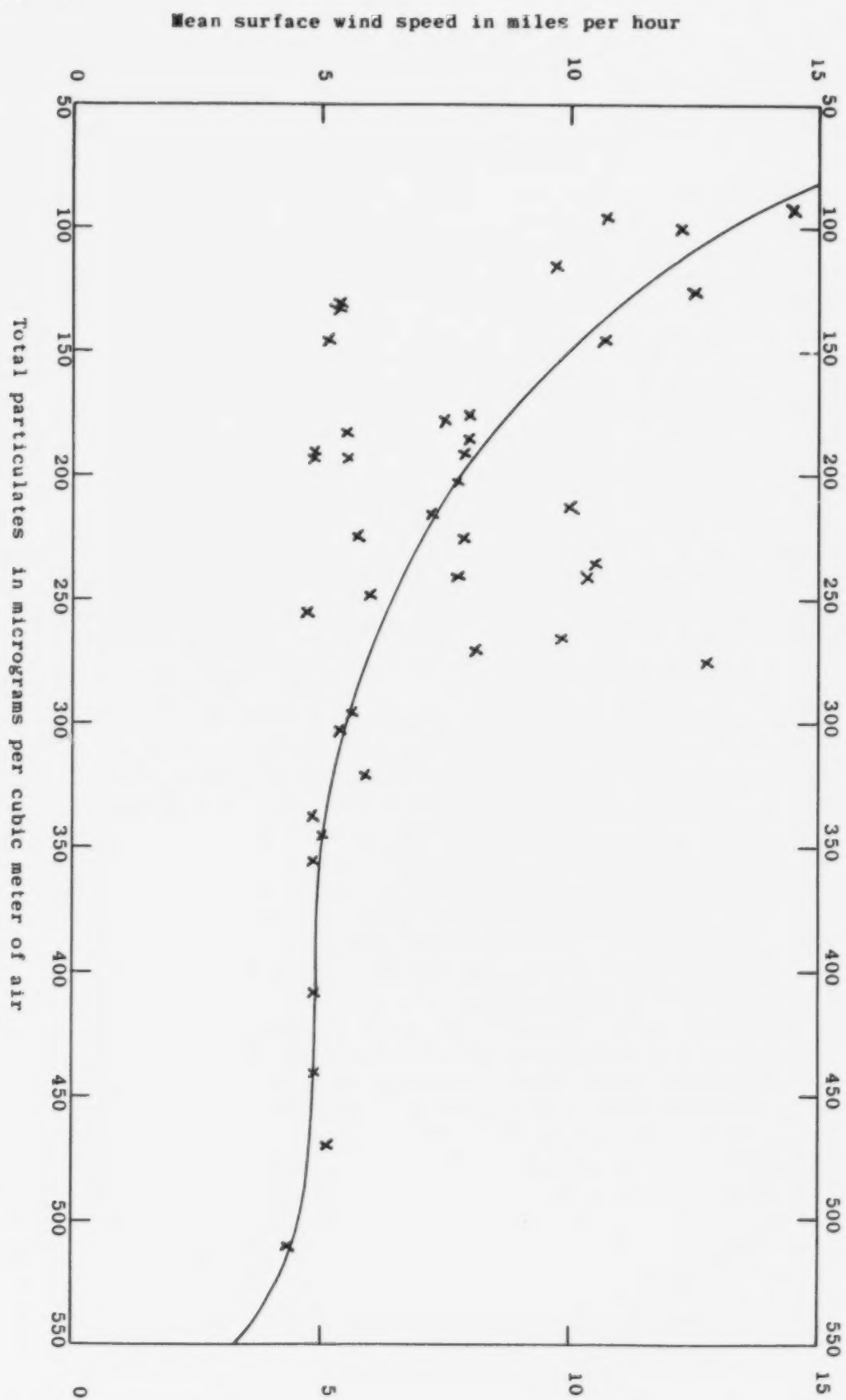


FIGURE 38 . Concentration of particulates versus mean surface wind speed

Figure 36 is a plot of the mean daily value of $T_{sfc} - T_{850}$ in degrees C where T_{sfc} is the surface temperature and T_{850} is the temperature at a pressure height of 850 millibars, both measured at Mount Clemens. The scale is arranged so that peaks in the curve indicate high stability (poor diffusion) and troughs indicate high instability (good diffusion). Figure 37 is a plot of the daily surface temperature anomaly at Detroit City Airport. Figures 36 and 37 are intended as alternate indices of low level stability. It will be noted that they become a little out of phase towards the end of each warm spell, but the agreement is generally good.

Comparing the curves of Figure 34 with Figures 36 and 37, it will be seen that the two periods of high pollution were marked by increased stability and above normal temperatures. The higher peak coincided with the greater stability and greater positive temperature anomaly. Even during some of the lesser fluctuations, the agreement between Figures 34 and 37 is quite close.

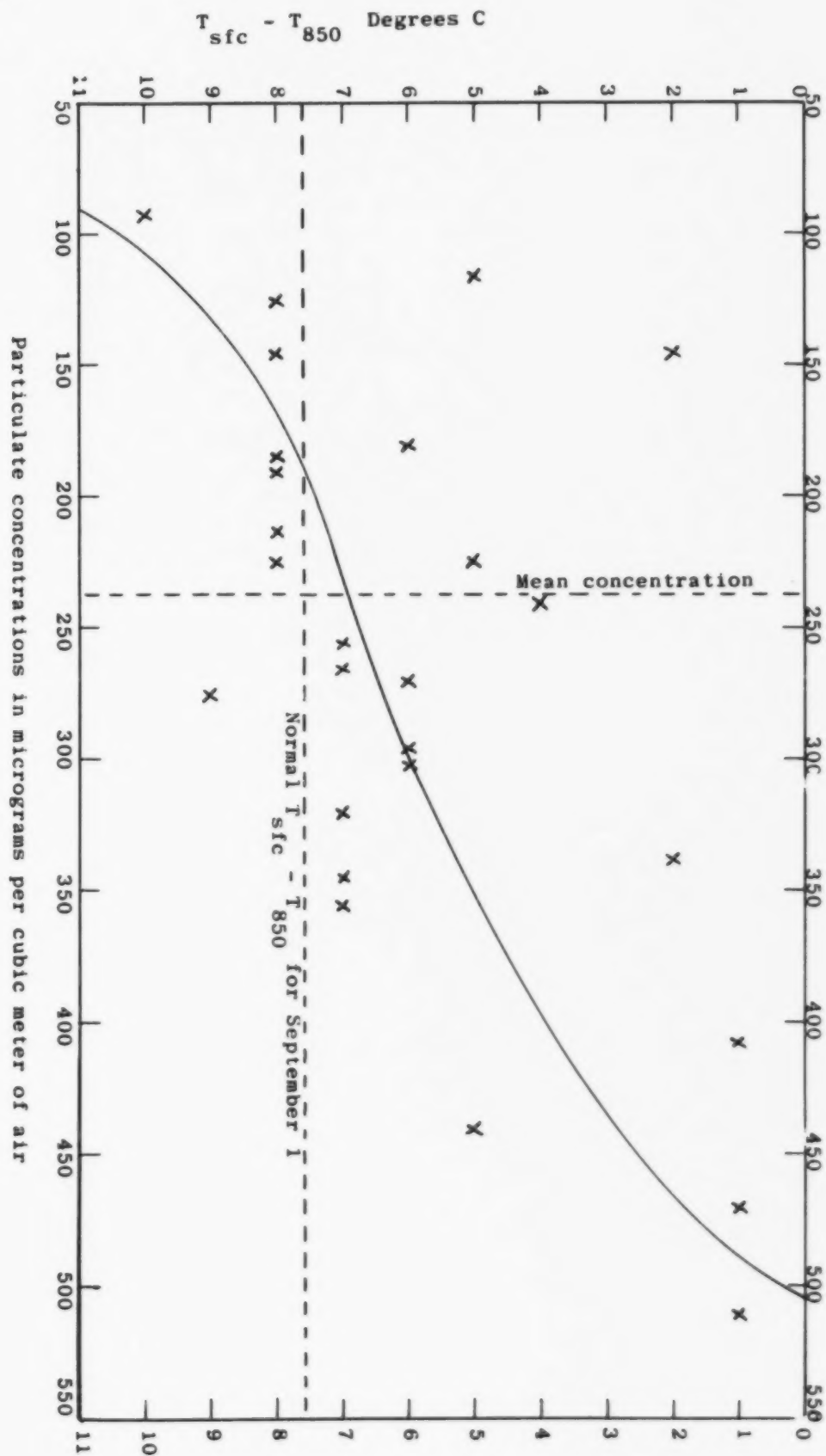
Figure 39 shows aerosol concentration plotted against $T_{sfc} - T_{850}$ for the twenty-six days on which radio soundings were taken. A line drawn among the points shows high pollution was associated with high stability and low pollution with high instability. As would be expected, there is considerable scatter among the points when differences in surface wind speed are ignored.

Supplementary lines were drawn on Figure 39 to show the mean aerosol concentration for the six weeks' study period, and the normal value of $T_{sfc} - T_{850}$ for September 1 as determined from records of the U. S. Weather Bureau. Only one above average pollution value occurred without above average stability. It may therefore be concluded that high stability is another requisite for high pollution.

Figure 40 is a plot of aerosol concentration against surface temperature anomaly. The smooth curve illustrates that high pollution tends to occur with above normal temperatures and low pollution with below normal temperatures. The great scatter of the points again emphasized that there was more than one requisite for high pollution.

Note that S-shaped curves have been drawn in Figures 38, 39 and 40 to illustrate that there were lower and upper limits to the pollution regardless of the extremes that may occur in the weather factors.

FIGURE 39. Particulate concentrations versus $T_{sfc} - T_{850}$



In conclusion, the results of this study reveal three meteorological requisites for high pollution. These are:

1. Low surface wind speed.
2. Very stable air as measured by $T_{sfc} - T_{850}$.
3. Above normal surface temperatures.

Effect of Changing Wind Direction

To investigate the effect of changing wind direction with an instrument which collects one sample every twenty-four hours, requires selecting days on which a single wind direction was observed for most of the entire twenty-four hours. During most day winds from several different directions will occur, so that the observed pollution cannot be assigned to a single wind direction. It was desired, however, to study the influence of northeast, southeast, southwest and northwest wind directions upon air pollutants.

A single day was chosen as representative of each of these four wind directions. The choice was made from the days on which all stations in both Detroit and Windsor were operating. Windsor Airport surface winds were used because its log of wind directions to only eight compass points, was more readily available.

The following choices were made:

1. For northeast winds, the twenty-four hours beginning at noon August 21, during which northeast winds were observed for twelve hours, and north and northwest winds for the other twelve hours.
2. For southeast winds, the twenty-four hours beginning at noon August 27, during which there were seventeen hours of southeast winds, two hours south, and five hours calm.
3. For southwest winds, the twenty-four hours beginning at noon September 4, during which there were twenty-two hours southwest winds and two hours south.
4. For northwest winds, the twenty-four hours beginning at noon September 3, the poorest of the four choices, during which there were sixteen hours of west winds, 7 hours northwest, and one hour southwest. Because of the marginal suitability of the wind directions, the report for Detroit City Airport was examined. Half hourly occurrences were as follows: WSW 3, W 19, WNW 23, NW 3.

FIGURE 40. Particulate concentrations versus surface temperature anomaly

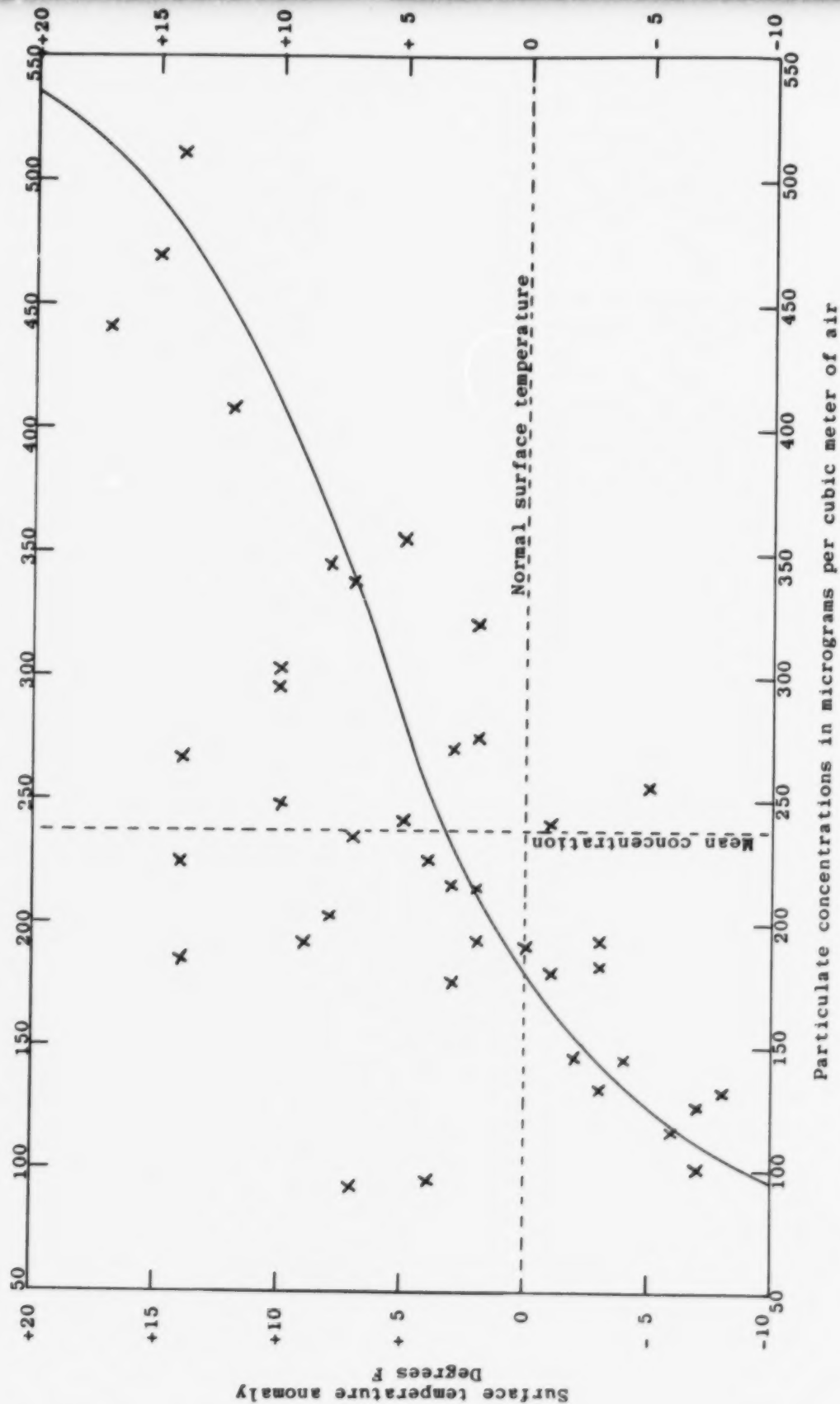
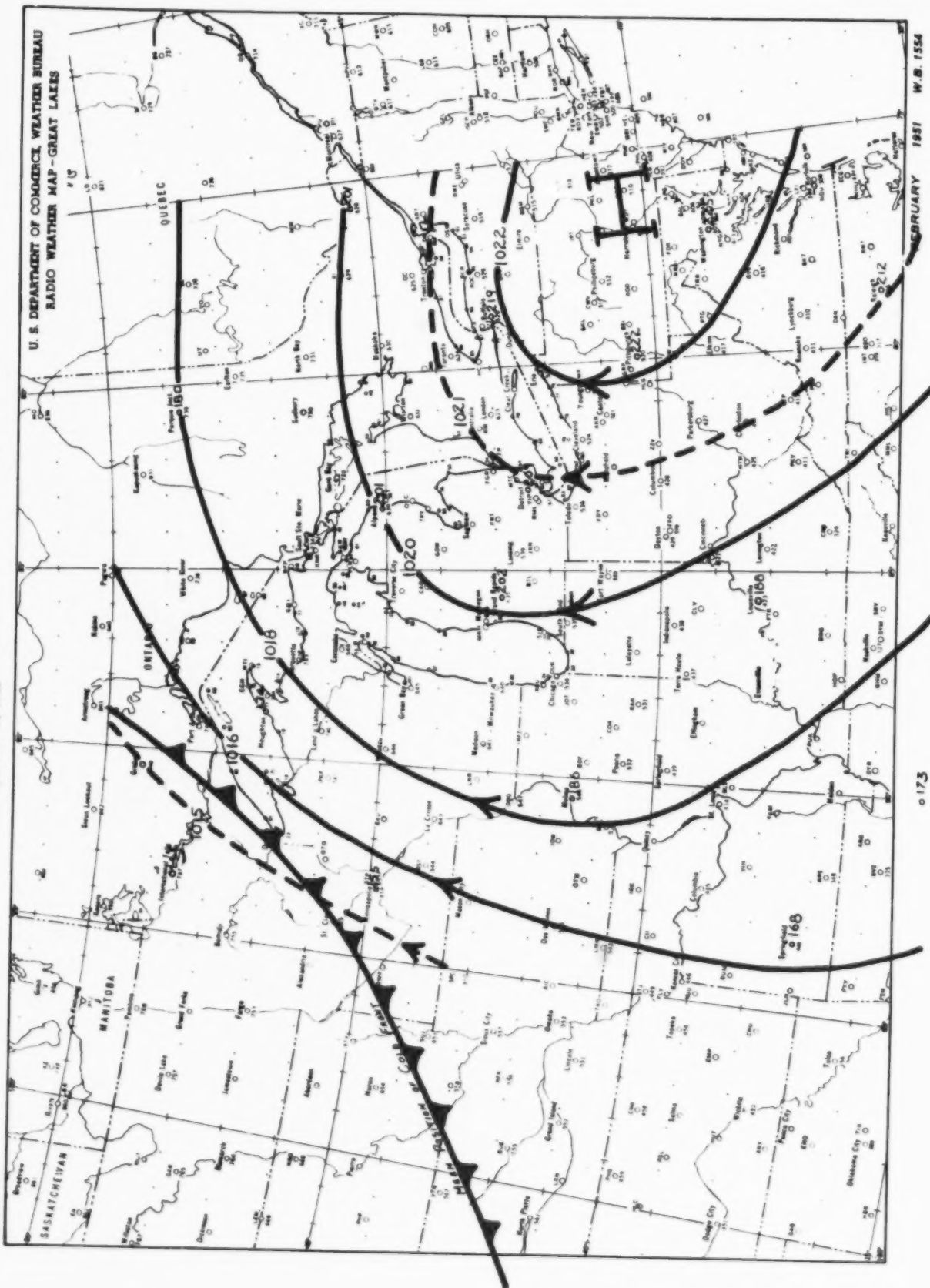


FIGURE 41. Average pressure distribution for two days which had the highest total precipitation concentrations during the period August 7 through September 19, 1952



The mean particulate concentrations for Detroit-Windsor for the four days were as follows: NE 100 micrograms per cubic meter of air, SE 296, SW 271 and NW 180 micrograms per cubic meter of air.

The lower concentrations with northerly wind may be explained by the known lack of pollution sources to the north of the Detroit River area and greater instability of northerly winds. The higher concentrations obtained with southerly winds may be due to the presence of pollution sources to the south and the high frequency of low level inversions in southerly winds.

It is worth noting that the report prepared by the U. S. Weather Bureau dealing with the spring of 1951 High Volume Sampler study concluded that "...with gradient wind flow between north and east, Detroit in the spring will, on the average, experience the lowest concentration of particulate pollution, while with south through west flow, it will experience the greatest concentrations of pollution".

Average Pressure Distribution for High and Low Pollution

The average pressure distribution for the ten highest pollution days and the nine lowest pollution days was determined. The area investigated was bounded on the south by 35 deg N lat, on the north by 50 deg N lat, on the east by 75 deg. W long, and on the west by 95 deg W long. The data in column one of Table 26 were used in selecting the days. The ten highest pollution days were August 26 through 29, September 9 through 13, and September 17. During these periods, the average mean sea level pressures for sixteen weather stations were computed from the 0030 EST pressures, and the isobars were drawn as shown in Figure 41. The isobars indicate that movement of air was from the south over the study area.

The average pressure distribution for the nine days of lowest total particulate concentrations has also been determined. The days were August 10, 12, 22, 23, September 2, 3, 7, 8, and 15. Average pressures were computed for thirteen stations during these periods. Figure 42 depicts the pressure pattern for the days which had lowest total particulate concentrations. A northerly flow is shown over the study area.

The striking difference in the location of the centers of high pressure in Figures 41 and 42 and the contrast between southerly and northerly flows is very informative. This further confirms the fact that northerly winds were cleaner than southerly winds.

To further define the general synoptic situation for the days of highest and lowest pollution, the mean position of the cold front was determined for each group, since it is apparent that the change from figure 41 to 42 will be accomplished by a cold frontal passage.

For the low pollution days the nearest cold front to the east of Detroit was considered, and for the highest pollution days the nearest cold front to the west was considered. To locate the mean position of the cold front, its points of intersection at latitudes 50, 45, 40, and 35 N were recorded at 0030 EST on each of the days, and the four mean points of intersection determined for each group.

Mean Synoptic Situation for Days of Highest Total Particulate Concentrations

A high pressure area was centered in the vicinity of Philadelphia with a ridge of high pressure west northwestward across southern Michigan. The cold front intersected 50 N 89 W, 45 N 95 W, 40 N 105 W, and 35 N 108 W.

Mean Synoptic Situation for Days of Lowest Total Particulate Concentrations

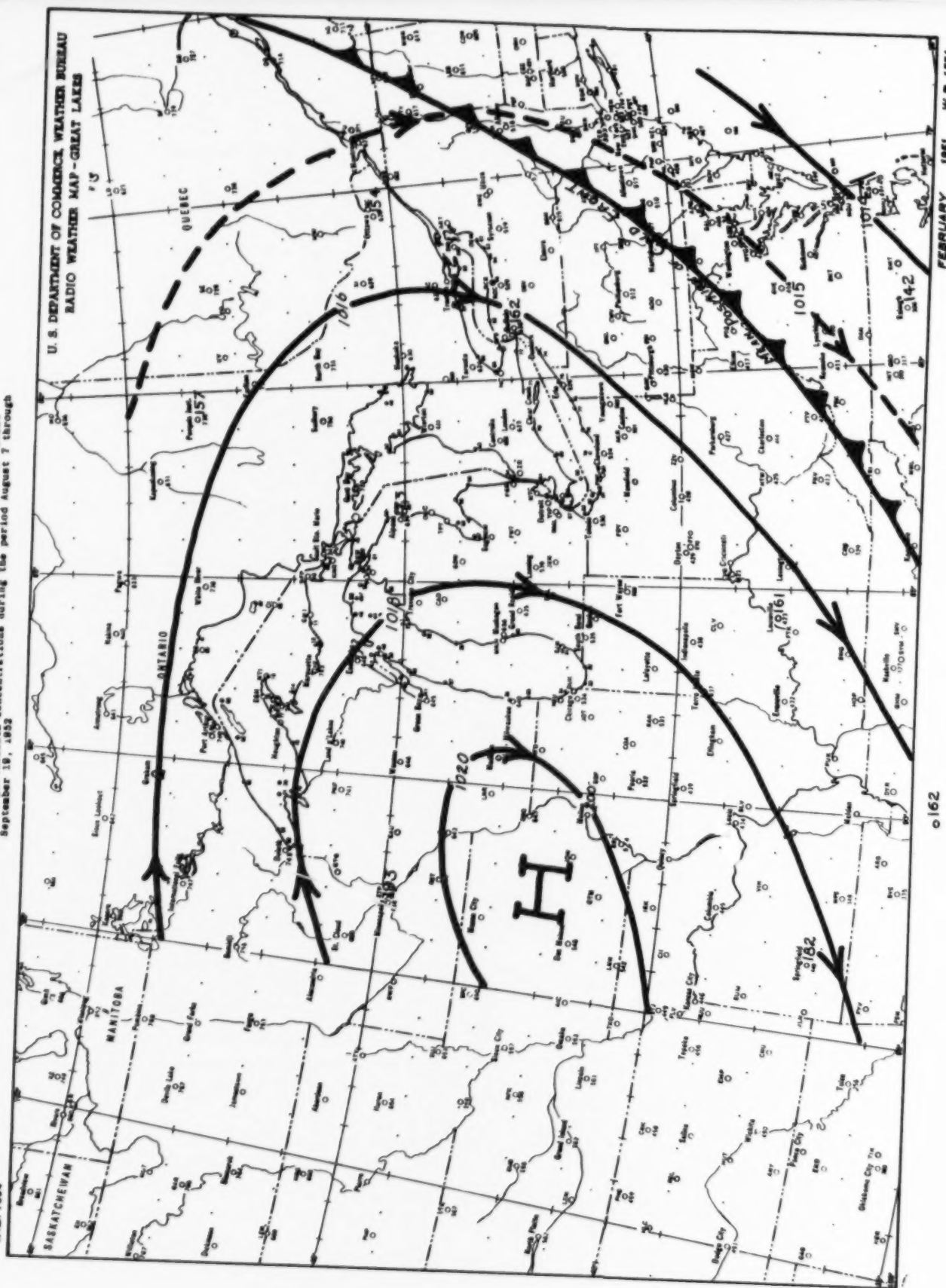
A high pressure area was centered over Iowa with a ridge of high pressure extending east northeastward across Lake Huron. The cold front intersected 50 N 68 W, 45 N 72 W, 40 N 77 W, and 35 N 86 W.

Influence of Cold Frontal Passages on Particulate Pollution

A cold frontal passage is effective in reducing pollution for many reasons. Some of these are: (1) immediately ahead of and behind the front, surface winds will tend to be strong; (2) the inflowing cold air will tend to be unstable; (3) the inflowing cold air generally comes from regions free of atmospheric pollution, and (4) cold frontal passages are commonly accompanied by rain, which is believed by many to have a cleansing action on the atmosphere.

Whatever the mechanism of the cleansing action of cold fronts, the effect is there. The preceding section showed a cold front not far past Detroit in the mean synoptic situation for the days of lowest pollution. The following discussion will emphasize the effectiveness of cold frontal passages during the study period.

FIGURE 42. Average pressure distribution for nine days which had the lowest total particulate concentrations during the period August 7 through September 19, 1954



There were nine cold frontal passages through Detroit during the study period according to the Daily Weather Map published by the U. S. Weather Bureau. The time of passage of each of the nine fronts was estimated from the twelve hourly positions as shown on published maps, the log of hourly temperatures for Detroit City Airport, and the six-hourly weather reports for Detroit City Airport. The times listed in Table 25 are believed accurate to within two hours. Table 25 records the observed decreases in pollution which appear to follow the passage of a cold front. Thus Table 25 shows that each cold frontal passage was associated with a cleansing of the air over the study area.

Effect of Rainfall on Particulate Pollution

At first glance it would appear that much could be deduced about the influence of rain on pollution from this study. There were, after all, eighteen days on which rain fell. But closer inspection reveals that rain was reported at Detroit City Airport on only 95 of the 1008 hours of the study. Of the total rainfall of 3.90 inches which fell during the study period, 71 percent fell on three days, (i.e. computed on a noon to noon basis), and cold frontal passages took place on each of these days. In fact most of the measurable rain accompanied cold frontal passages. In the light of the results of the preceding section, analysis of this set of data will hardly provide evidence of the exclusive influence of rain in decreasing particulate pollution.

As far as this study is concerned, the effect of rainfall must remain an open question. Perhaps hourly samples of particulates, together with hourly rainfall occurrences in the absence of frontal passages, may provide an answer. However, no data of this type are available at the present time.

Conclusions

1. Particulate pollution in the Detroit-Windsor area was inversely related to the surface wind speed.
2. Particulate pollution was directly related to the stability of the air.
3. Periods of high particulate pollution tended to occur during abnormally warm weather, while periods of low pollution tended to occur during abnormally cool weather.

TABLE 25. Cold frontal passages and related decreases in particulate pollution

Time of frontal passage	Time of removal of filters	Percent of particulate pollution on previous day
Aug 092200 EST	101200 EST	47
120300	121200	72
160900	161200	81
160900	171200	87
211100	221200	43
291200	301200	63
Sept 011600	021200	79
060900	071200	48
150100	151200	35
180600	181200	66

4. Particulate pollution was highest with southerly winds, and lowest with northerly winds.

5. Cold frontal passages were an effective mechanism for reducing the levels of particulate pollution.

6. There was no evidence from this study to either support or refute the theory that rainfall alone can effectively reduce particulate pollution.

Conclusions based on such a short study may uncover fundamental relationships or may result from some accident of the sampling procedures. Conclusions 1 and 2 confirm basic rules and can be accepted. Conclusion 5 is eloquently supported by the fact that cold frontal passages ended both the Donora smog of October 1948, and the London smog of December 1952. Conclusions 3 and 4 are probably generally true, at least for this season, since they are closely related to stability. However, it has not yet been established that abnormally warm air means abnormally high pollution at any season of the year.

VIII APPENDICES

APPENDIX I.

During the six weeks study period, samples were collected at all Windsor stations Monday through Friday. On Saturdays and Sundays only two stations were operated. In Detroit, samples were collected at all stations Monday through Thursday. On Friday, Saturday and Sunday, three stations were operated.

Average particulate concentrations based on two or three stations can be expressed as a fraction of the averages based on all stations. An estimate of the size of this fraction can be determined from the days on which all stations operated. This fraction can then be used to compute estimates of the average of all stations for days when only two or three were operated. Since the treatment will be statistical, it will also be possible to give fiducial limits for the estimates obtained.

The net result of this treatment will be a record of particulate concentration for every day of the study rather than a record interrupted twice weekly at Windsor and three times weekly in Detroit. Such a complete record is a great advantage in looking for meteorological correlations, even though a substantial portion of the record is based on estimation rather than measurement.

The average particulate concentration for Windsor was established by eight stations. Only Stations 1 and 7 were operated on weekends. From the twenty-nine days on which all stations were operated, it was computed that the mean particulate concentration of Stations 1 and 7 was 94 percent of the mean based on all eight stations. The 95 percent fiducial limits were 94 ± 5.5 percent. With this information and the average of Stations 1 and 7, estimates of the average based on all eight stations were computed for weekends. Table A summarizes these computations.

The average particulate concentration for Detroit was established by nine stations. Over weekends the reduced operation sometimes consisted of Stations 12, 24, and 28, sometimes of Stations 12 and 24, sometimes of Stations 24 and 28, and once of Stations 12 and 28. The computations made for each of these combinations are summarized in Table B.

Table C lists the estimates of the average particulate concentration over Detroit for the weekends, based on the figures in Table B and the average particulate concentration as indicated by the reduced weekend operation.

The estimates provided in Tables A and C made it possible to complete the record for both Windsor and Detroit with one or two exceptions due to instrument failure. Detroit and Windsor data were combined since this was a single study carried on in a single area and daily running means of particulate concentrations were computed in order to smooth out small day to day trends which were not related to large scale influence.

Table D is a final summary of the pollution data, including the estimates of Tables A and C combining the Detroit and Windsor data into an area average, and providing a running mean of the area average. These were the data used in investigating the influence of meteorological factors on changes in the pollution level.

TABLE A. Estimates of average aerosol concentration over Windsor based on Stations 1 and 7

Date	Micrograms per cubic meter of air	
	Aerosol Concentration Stations 1&7	Estimated Aerosol Conc All stations and 95% Fiducial Limits
Aug 10	46	49 $\pm$ 3
11	186	197 $\pm$ 10
17	71	75 $\pm$ 4
24	162	173 $\pm$ 9
25	224	238 $\pm$ 12
31	174	186 $\pm$ 10
Sept 1	169	180 $\pm$ 9
2	143	152 $\pm$ 8
7	73	78 $\pm$ 4
8	87	93 $\pm$ 5
14	164	175 $\pm$ 9
15	72	76 $\pm$ 4

TABLE B. Relationship of aerosol concentrations between
certain groups of stations and all nine stations

Stations in Group	Average of Group Stations as Percentage of Average of all Stations and 95% Fiducial Limits
12, 24, 28	77 ± 7.2
12, 24	81 ± 9.0
24, 28	73 ± 9.0
12, 28	77 ± 7.4

TABLE C. Estimates of average total aerosol concentration (in micrograms per cubic meter of air) over Detroit based on data obtained from two or three stations

Date	Average Aerosol Concentration S T A T I O N S				Estimated Aerosol Conc. All Stations and 95% Fiducial Limits
	12, 24, 28	12, 24	24, 28	12, 28	
Aug 10	-	116	-	-	143 ± 10
11	-	137	-	-	169 ± 12
16	-	227	-	-	281 ± 20
17	-	224	-	-	277 ± 20
18	-	103	-	-	127 ± 9
23	-	-	-	115	150 ± 9
24	262	-	-	-	340 ± 19
25	162	-	-	-	210 ± 12
30	246	-	-	-	320 ± 18
31	202	-	-	-	263 ± 15
Sept 1	-	-	137	-	188 ± 12
2	107	-	-	-	139 ± 8
6	-	-	148	-	203 ± 13
7	-	-	112	-	153 ± 10
8	-	-	145	-	198 ± 13
13	434	-	-	-	563 ± 31
14	276	-	-	-	358 ± 20
15	82	-	-	-	107 ± 6

TABLE D. Mean concentration of particulates (in micrograms per cubic meter of air) in Detroit and Windsor, including estimates, for the period August 8 through September 18, 1952

Date		Total Particulates			
		Calculated Mean Concentration		Mean Concentration Detroit-Windsor	Running Mean Concentration Detroit-Windsor
		Windsor	Detroit		
Aug	8	182	272	192	-
	9	203	-	-	174
	10	49	143	96	144
	11	197	169	183	148
	12	94	170	132	160
	13	182	201	192	189
	14	143	339	241	230
	15	180	317	248	235
	16	124	281	202	207
	17	75	277	176	-
	18	-	127	-	-
	19	182	198	190	-
	20	152	279	215	214
	21	183	288	235	196
	22	58	142	100	142
	23	113	150	131	154
	24	173	340	256	217
	25	238	210	224	265
	26	300	412	356	320
	27	299	388	344	335
	28	287	304	296	310
	29	268	335	302	273
	30	62	320	191	227
	31	186	263	224	206
Sept	1	180	188	184	184
	2	152	139	146	150
	3	134	118	126	144
	4	192	168	180	189
	5	242	299	271	240
	6	278	203	240	217
	7	78	153	116	154
	8	93	198	146	186
	9	313	353	338	307
	10	409	404	407	416
	11	500	522	511	474
	12	410	528	469	472
	13	319	553	441	404
	14	175	358	266	266
	15	76	107	92	181
	16	260	291	275	241
	17	289	354	321	282
	18	158	259	213	-

APPENDIX II.

Because of the bearing of weather on pollution, it is interesting to consider to what extent the weather of 1952 differed from the long time average. In Table E, monthly values for 1952 of temperature, precipitation, prevailing wind direction, and mean wind speed are compared to the long time average. By referring to the table, it is possible to see wherein the weather of 1952 departed from the long time average. All the data were taken from the United States Weather Bureau summary, "Local Climatological Data with Comparative Data, 1952, Detroit, Michigan".

TABLE E. U. S. Weather Bureau Records of Weather means for Detroit

Month	Temperature Deg. F		Precipitation Inches		Prevailing Wind		Wind Speed mi/hr	
	1952	79 yr mean	1952	82 yr mean	1952	43 yr mean	1952	71 yr mean
Jan	29.3	25.3	3.22	2.12	NW	SW	10.4	11.8
Feb	29.3	25.5	1.60	2.12	NW	SW	9.7	11.7
Mar	34.3	34.3	3.25	2.46	NW	SW	10.2	11.7
Apr	49.6	46.2	3.45	2.63	NNE	SW	10.9	11.4
May	57.3	57.9	2.87	3.41	WNW	SW	9.8	10.2
June	72.7	67.9	1.06	3.35	E	SW	10.1	9.4
July	76.5	72.9	3.14	3.20	S	SW	8.9	9.0
Aug	71.5	70.8	2.18	2.71	S	SW	7.2	8.8
Sept	64.8	64.1	2.30	2.69	S	SW	8.4	9.5
Oct	48.1	52.6	1.46	2.39	W	SW	11.3	10.2
Nov	42.8	39.7	2.87	2.34	S	SW	11.1	11.7
Dec	34.1	29.3	1.94	2.28	W	SW	10.5	11.7
Year	50.9	48.9	29.34	31.70	W	SW	9.9	10.6

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